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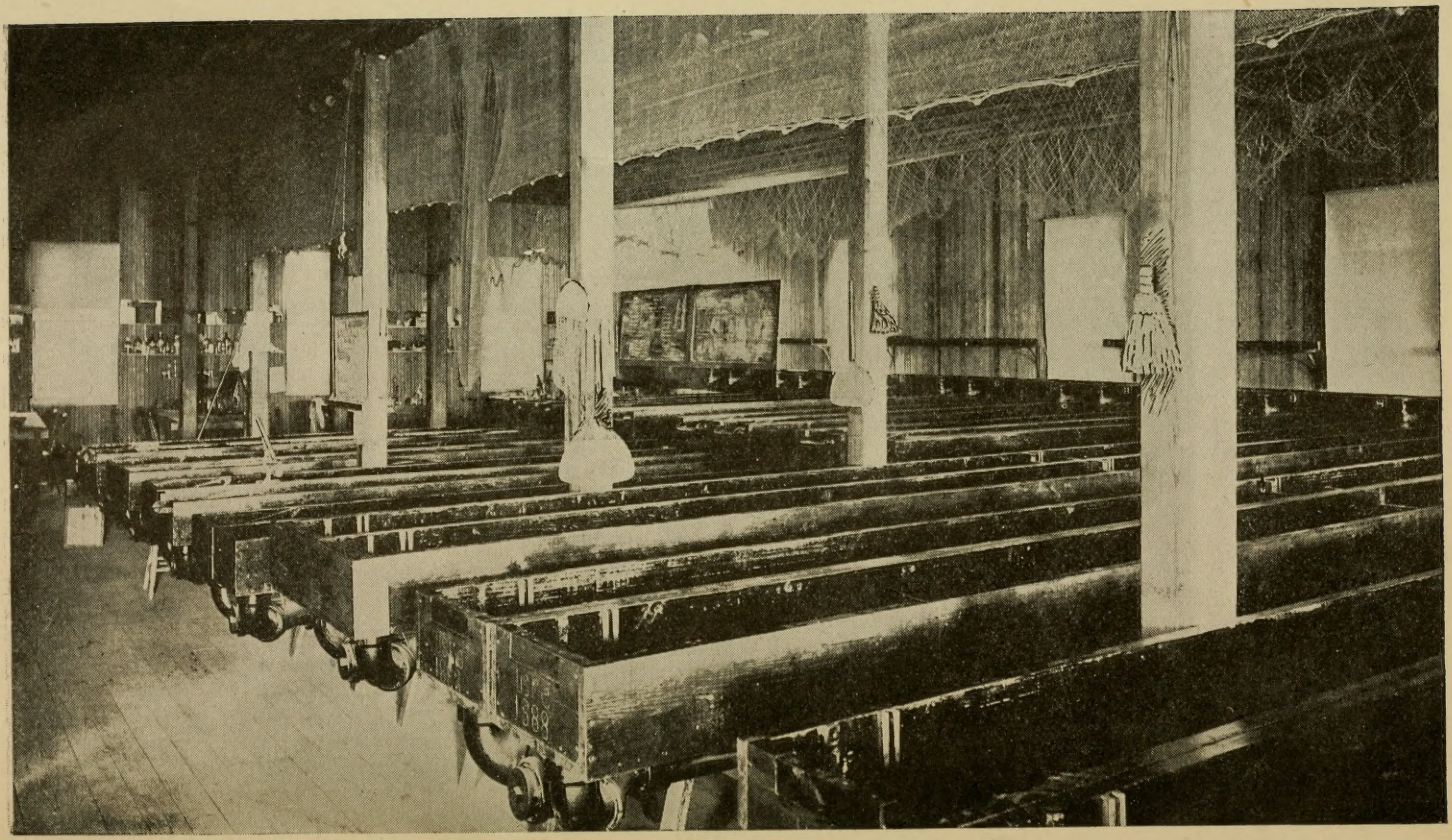

INTERIOR OF STATE HATCHERY AT COLD SPRING HARBOR, N. Y.

MODERN

FISHCULTURE

IN

FRESH AND SALT WATER

BY

FRED MATHER

Author of "Men I Have Fished With"

FORMERLY ASSISTANT TO THE U. S. FISH COMMISSION, LATE SUPERINTENDENT OF THE N. Y. STATE HATCHERY AT COLD SPRING HARBOR, LONG ISLAND,

WITH

A CHAPTER ON WHITEFISH CULTURE BY HON. HERSCHEL WHITAKER, FISH COMMISSIONER OF MICHIGAN, AND A CHAPTER ON THE PIKE-PERCH BY JAMES NEVIN, SUPERINTENDENT OF THE WISCONSIN FISH COMMISSION.

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FOREST AND STREAM PUBLISHING COMPANY

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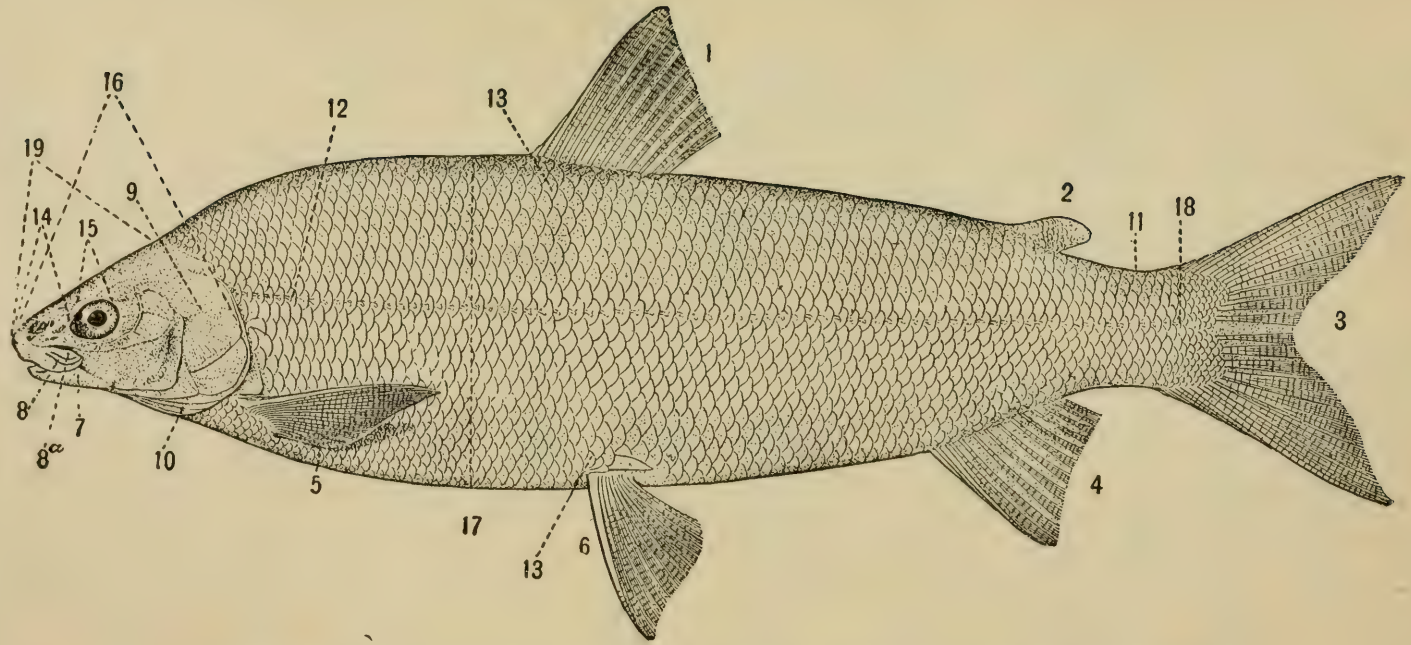


FIGURE OF A FISH SHOWING THE PARTS USUALLY REFERRED TO IN DESCRIPTIONS.
From "A Manual of Fishculture" by the U. S. Fish Commission.

1. Dorsal fin.
2. Adipose fin.
3. Caudal fin.
4. Anal fin.
5. Pectoral fin.
6. Ventral fin.
7. Lower jaw, or mandible.
8. Upper jaw, or maxillary.
8*a*. Supplemental maxillary.
9. Opercle.
10. Brachiostegals.
11. Caudal peduncle.
12. Lateral line.
13. Series of crosswise scales usually counted.
14. Snout.
15. Eye.
16. Head.
17. Depth.
18. Base of caudal.
19. Distance from snout to nape or occiput.

WHY THE BOOK WAS WRITTEN.

When I began fishculture in 1868, by buying a farm near Honeoye Falls, Monroe County, N. Y., to begin raising trout, there was little available literature on the subject. The only book I knew of was a book entitled "American Fishculture, embracing all the details of artificial breeding and rearing of trout, the culture of salmon, shad and other fishes," by Thaddeus Norris. It was published that same year and gave what was then known of the subject, and by its feeble light I began work, but found that I had it all to learn.

Fifteen miles west of me a man was breeding trout, but he did not approve of what he considered an invasion of his particular domain, and no information could be had in that quarter; so I learned my lesson by many expensive experiments and mistakes.

The sale of eggs and fry was the most profitable part of trout farming then, and Mr. A. S. Collins, Dr. J. H. Slack and I called a meeting to agree upon a scale of prices. The preliminary meeting was held in New York in 1870, but the following year we met in Albany and organized The American Fishculturists' Association, with some twenty members. Papers on fishculture were read, but the sale of eggs and fry did not come up; we took a broader course. Massachusetts, New York, Connecticut and other States had organized Fish Commissions, and we adopted a resolution that the general Government should have something of the kind, and appointed Mr. George Shepard Page a

committee of one to go to Washington and lay the matter before Congress. He did this, after consulting Prof. Spencer F. Baird, then Assistant Secretary of the Smithsonian Institution. To avoid all struggle for the office, Prof. Baird had a clause inserted that the Commissioner should serve without salary, and he was appointed to be Fish Commissioner in 1871.

Prof. Baird called me to assist in the shad hatching on the Hudson and the Connecticut rivers, and in 1874 sent me to Germany with 100,000 young shad. I was again sent to Germany with eggs of quinnat salmon in 1877, and also in 1879. I had devised a refrigerating box for salmon eggs which was a success; but, like my conical apparatus for hatching shad eggs in bulk, it was not patented.

In 1880 Prof. Baird appointed me to the charge of the American exhibit of angling and fishcultural apparatus at the International Fisheries Exposition held in Berlin, Prof. G. Brown Goode representing the Commissioner.

When Mr. Eugene G. Blackford was made one of the Fish Commissioners of the State of New York he wanted a hatchery on Long Island. Seth Green, the Superintendent of the Commission, opposed it and said there was no fit place on the Island. Mr. Blackford engaged me to examine the waters and to report. I reported that at Cold Spring Harbor was a fine place for both fresh and salt water fishculture, and I secured the place for the Commission from its owner, Mr. John D. Jones, without cost to the State. This was in 1882, and that winter I began hatching salmón for the Hudson, for the United States Fish Commission at Roslyn, Long Island, and Green sent a man to put troughs in an old building at Cold Spring Harbor, but soon re-

called him. Mr. Blackford then asked me to take charge of it, which I did on January 1, 1883, and four years later planned and built the present hatchery, which is not only the best, but is also the most important one in the State. There I learned how to hatch over 70 per cent. of the adhesive eggs of the smelt, and in the hatching of lobsters discovered that they spawn only once in two years. Changes in the Commission threw me out in 1895.

These things are mentioned merely to show that I have some right to opinions on fishculture after an experience of thirty years, and, there being no modern book on general fishculture, outside of the Government publications, such a book has been asked for; but as trout breeding is not only the parent of fishculture, but the most popular form of it, a large portion of the book is devoted to that branch, and I hope that the novice may profit by it and avoid many failures which fell to the lot of those who were the pioneers in this work.

On methods where fishculturists differ about details I have given the opinions of some of the best informed men in America, and in the culture of whitefish and wall-eyed pike, where my own experience has been little or nothing, I have asked well-known men of experience to write these chapters in order that the book may be as nearly perfect as possible. Fishculturists may differ with me on some small matters, but that is to be expected, and will not affect the general result.

The book has been many years in preparation in the way of gathering material, circulars having been sent to fishculturists in 1891 concerning the feeding of fry in troughs and of the diseases of adult trout, the answers to which will be found under those heads.

Naturally, reference is frequently made to my own

work and experience, but this is the only work on fishculture in any language which gives the experience of others, although one or two of the older ones occasionally hint that there were some dabblers in the art at the time they were writing.

As this book is intended to be original, I have refrained during the past five years from looking into any fishcultural work, outside the Government publications, for fear that I might unconsciously quote the author. When the opinions of others seemed to be needed on mooted points, they were written to and their answers are given.

Last, but not least, the book was written because the publishers have been flooded with demands for such a work, and, outside of Government publications, there is no book which covers the whole ground since Norris published "American Fishculture," in 1868, now long out of print.

These seem to be good and sufficient reasons for the existence of a book on Modern Fishculture.

F. M.

April 20, 1899.

A GLANCE AT FISH CULTURE.

Hundreds, and perhaps thousands of years ago, the Chinese placed twigs in the water to catch the adhesive spawn of some species of fish. This is the extent of the work done by them, only this and nothing more. The eggs were placed in other waters and left to hatch. As it has been claimed that they were far ahead of us in fishculture, I made inquiry of learned Chinamen at the Fisheries Exposition in Berlin in 1880, and know that their fishcultural work is of the crudest sort, and has not improved. In the United States the work has made the greatest strides and has been prosecuted on a scale not equalled elsewhere. Then come Canada, Germany, Norway, Sweden and other countries, but England has done nothing in a public way; fishculture there is entirely in private hands and is confined to private waters, largely on the estates of wealthy gentlemen.

The question is often asked, "Will it pay to raise trout?" So much depends upon local conditions that only a general answer can be made. If the water supply is large and not too warm; if food can be had in plenty at a very low price and there is a good market near, then it will pay to raise trout for market, if you can do it on a sufficiently large scale; or, if there are anglers near who will pay for what they catch, they form the best market. There are places where trout can be grown for food in limited numbers without expense, and the price received is nearly all profit. If the waters are too warm for trout they can be made to produce other fish, such as black bass or perch; or if not these,

then carp, which I do not look upon with favor. All these subjects will be treated at length under their respective heads.

Fishculture—and I always prefer this word to the Latin, pisciculture, as I do the good English word eggs to ova—is a paying investment for the government and for such States as have suitable waters. If New York had not hatched shad in the Hudson each year since 1869 there would be few or none there now. The increase of population, and above all the facilities for transportation, are so great that the drain on the river would be more than it could stand. North River, another name for the Hudson, shad are now sent to Chicago, and beyond, and the number of fishermen has increased with the demand for shad. This is why shad do not become cheaper when so many more millions are hatched. They seldom sell for less than $10 per hundred at the nets. As proof of the assertion that shad would be nearly extinct in the Hudson but for artificial hatching, I will cite the case of the Connecticut River, once so famous for the number as well as the quality of its shad. Years ago there was an arrangement to share the expense of shad hatching by the States of Massachusetts and Connecticut, and they turned out many fish. Then the commissioners quarreled; the men of Massachusetts complained that they did not get their share of the shad, because the pounds at the mouth of the river took the bulk of the fish. The hatching stopped some twenty years ago, and now the Connecticut furnishes very few shad, so few that it does not pay to fish for them above the mouth of the river. There was a similar dispute about the salmon in the Rhine; Germany hatched them and Holland caught them, reaping the benefit without any expense.

Shad only come to the rivers to breed. Those caught for food when ripe are lost for that purpose unless the fishculturist saves them, and he hatches millions which would otherwise be lost.

Again the Connecticut River. It was once a famous salmon river. My grandfather has told me of seeing his father, Joseph Mather, who ran a ferry from Lyme to Saybrook, at the mouth of the river, over 125 years ago, take so many salmon in his net that he could not land them for fear of tearing the net, and part had to be released. In the late 70's the salmon had not been seen in the river for over a quarter of a century, and the States above mentioned, in connection with Vermont, New Hampshire and the United States, shared the expense of restocking the river with salmon fry from the Penobscot. The salmon fishery was restored and in a few years Connecticut salmon were common in the markets of New York, Boston and other cities. Then came the old trouble about the nets at the mouth of the river and the stocking ceased. The run of fish kept up for two or three years afterward and Connecticut salmon were no longer caught.

It is difficult to tell the results of fishculture in waters where the fish which are bred have always existed, but when a species is placed in water where it is not a native, and thrives there, the fishculturist can point to it with pride. Shad and striped bass were unknown on the Pacific coast until planted there over twenty years ago, and now they are not only plenty in the Sacramento River, where the plants were made, but shad have strayed north and stocked waters as high up as Puget Sound. Not only that, but Mr. Blackford has seen shad in California which weighed as high as 16 pounds, while one of half that size is a monster on the

Atlantic coast. Striped bass are also common there. The salmon and the brown trout have been introduced into Australia, the rainbow trout into England and Germany with marked success, and if more examples are required I would refer to the introduction of the brown trout of Europe into America; but these are enough to show that the so-called artificial breeding of fish is a valuable industry if carried on intelligently.

The broad, unqualified assertion that "an acre of water is more valuable than an acre of land," started by some enthusiastic fishculturist years ago, is liable to hurt the cause of fishculture if used seriously. There can be no such comparison. Land and water are valuable for what they will produce; some land is worthless and so is some water, yet we must admit that the latter might produce more food than it does, for outside of Great Salt Lake I do not know of any American waters, unless alkaline ones, which will not produce food of some kind fit for the use of man, while I do know of barren sands that would not grow an ounce of food. The fact is that some acres of water are worth more than some acres of land, and *vice versa*. There is no fixed rule or ratio of values. I know of a spot where springs well up on about 40 acres of swamp land within as many miles of New York City, and make a splendid trout stream, which I would prefer to an equal amount of the best farming land in the State; but that is an exception. The Great Lakes do not yield as valuable products as an equal area of the best farming land. But then the Great Lakes are in a state of nature, the fishes in them are not selected, and worthless species prey upon the more valuable ones. Perhaps that's not a fair comparison, and I wish to be fair. Take the mill-pond of 20 acres. Here the water may be drawn off and in some

cases the worthless species can be killed. Then it is a question of temperature, location and other things which will determine its value with an equal area of land. There is no fixed value for either land or water, therefore the assertion quoted is absurd and misleading.

The rearing of some fishes is attended with more care than that of others; for instance, the trout may be raised in several different ways involving more or less care and expense in the preparation of ponds, hatching apparatus, etc., according to the system adopted, which is dependent upon the amount of flow, extent of ponds and the inclination of the owner—and here let me say that in the culture of fishes there are none which require as much care as the trout. It is very particular about the temperature in which it will live, anything above 75 degrees Fahrenheit, except in swiftly running water, being fatal; therefore its culture is prohibited in all waters where the bottom temperature rises above that figure. Few fish eggs are easier to care for and hatch than those of the trout, coming as they do from October to March, as any running stream is then cold enough, even though its summer temperature would be fatal to the young fish, and the eggs will endure any degree of cold short of freezing solid, even if surrounded by ice. As an offset to this, the young are delicate if kept in confined quarters, as they are likely to be if hatched in great numbers, and not turned into a stream or pond well supplied with natural food, but kept to be fed by hand; and although 90 per cent. of the eggs may easily be hatched and the greater portion of them may live during the embryonic period in which they are subsisting upon the yolk sac, which remains attached to the abdomen for a period of forty to fifty days before they need food, they are then apt, as before stated, to die very rapidly, and if

75 or 80 per cent. of the young are kept through the month of May, it is, in my opinion, a good average, and much more than I did in my first three years of trout culture. In those days there was no one to give the results of experience, at least none who would do so, and we had to blunder through and profit the next season by the dearly-bought experience of the last. A young trout which is safely brought through the month of May has passed all infantile dangers and is almost as good as raised.

The culture of the carnivorous fishes is attended with more dangers than that of others, as in addition to the number of enemies they will devour their own kind; and the trout is a truly carnivorous fish, notwithstanding the fact that it has been starved into eating corn bread and other vegetarian diet. This habit necessitates the keeping of the different sizes apart, if small ponds are used, and increases the care and trouble.

Of our other carnivorous, or perhaps piscivorous fishes, there are few or none which are worth the attention of the farmer, or which could be made a source of much food or any profit. Waters are stocked with the black bass for the sport of catching them; but they produce but little food, while the pike or pickerel (*Esox*) which are caught for sport are so fearfully destructive that anglers protest against their introduction into any waters not inhabited by them. In order to bring the habits of fishes and their different characters more plainly before the minds of those who have never studied them closely, they might be compared, in respect to their food, to certain well-known quadrupeds, in a general sort of way, first stating that there are no fishes which are so strictly vegetarians as some mammals are. We may then compare the pike, bass, and perch to the car-

nivorous cats, as the pike eats nothing but fish, while the other two vary their diet with an occasional worm or fly; the trout, when wild, may be also classed with those fishes, but under domestication its appetite, like that of the domestic dog, can be changed into one nearly resembling that of the omnivorous hog. This, however, requires to be received with some caution, as, although trout have been kept on corn bread and "dog biscuit," and are reported, by apparently good authority, as thriving upon that diet, yet it remains to be proved that they will breed freely under those conditions. If so, then, and not until then, it can be claimed that trout have been turned into vegetarians. Still this fish is not so much of a fish eater as those named above until it reaches a weight of over a pound, when it needs a more substantial meal than flies and worms, although it still takes them as *entrees*.

Perhaps those of our native fishes which more nearly resemble the herbivora—at least in their gregarious habits, if not entirely in diet—are included in the families known to scientists as the *Cyprinidæ* and *Catostomidæ*, which may be said to include all the toothless fishes of our fresh waters which have only one dorsal fin, composed entirely of soft rays, excepting the herring-like forms. The largest of these are the sucker tribes, which, in the tributaries of the Mississippi, often reach a weight of eight to ten pounds in the species locally known as "buffalo" and "red horse." But they are not worth raising, for the carp is in the same class, is a better table fish and is easily raised, but it is of little value in the cool waters of the North and will be considered later.

Fishes are as susceptible to the influences of domestication as any other animals, and perhaps our brook trout

may a century from this begin to show changes in favor of early maturity, hardihood, and freedom from early death by the continued breeding from the strongest, if our breeders will not resort to the practice of introducing wild stock into their ponds, thereby neutralizing all their efforts in this direction. Mr. Stone talks of "Domesticated Trout," and why not? The carp introduced from Germany shows what can be done in this line. It is a great improvement over the English carp. The Germans produced a quick-growing fish, and by selection bred the scales off from it.

The carp is not the only fish which shows signs of improvement under domestication. The Chinese and Japanese have for centuries bred the gold fish for ornamental purposes, and have produced results that are singular in their "telescope fish," that have projecting eyes which seem almost to be placed on stalks; some of these which were in the writer's possession had eyes fully a quarter of an inch out from the head, a position in which they would be so liable to injury in a state of nature that the fish could not live. Another form is with the long, drooping, soft tail of the kingio, which was loaned by Mr. Gill, of Baltimore, to the old New York Aquarium, and for which he was said to have refused $2,000.

Such abnormal fishes are produced by continued selection, in the same manner as our improved breeds of cattle are; but American fishculturists have never paid any attention to the ornamental part of their business, being engaged in trying to produce food fishes, or those which may be called "angler's fishes," all of which are of more or less value for the table.

In a private way there are a few who have made trout culture for market moderately profitable, and these have

had exceptional facilities in the manner of a supply of water and cheap and abundant food for them; yet there is a chance, even with the smallest of streams, of so cultivating the water, which is now a waste so far as the production of food is concerned, that it will at least furnish the family table with a welcome variety of wholesome food at a small outlay. The fact has been demonstrated that intelligent fishculture is one of our industries that those who have facilities for it are unwise to neglect.

SECTION I.

TROUT BREEDING.

CHAPTER I.

INTRODUCTION.

The breeding of trout was the beginning of fishculture, and this was first practised in 1741 by Stephan Ludwig Jacobi, a lieutenant in the German Army, living at Hoenhausen, a small town in Westphalia. The claim that the monk, Dom Pinchon, bred trout in the fifteenth century is not well supported. Jacobi reported his discovery some years after to the great naturalist, Buffon, and the British Government granted him a pension. In 1837 Mr. John Shaw, of Drumlaurig, hatched salmon from eggs taken by hand in Great Britain. The first work of the kind in America was done by Dr. Theodatus Garlick and his partner, Prof. Ackley, in 1853; but at that time it was regarded as merely a curious experiment, having no bearing on the question of producing food. Public attention was first called to fishculture in America in 1856 by an act of the Massachusetts Legislature appointing three commissioners to report such facts concerning the artificial propagation of fish as might tend to show the practicability and expediency of introducing the same into the Commonwealth under the protection of law. In 1859 Mr. Stephen H. Ainsworth,

of West Bloomfield, N. Y., bred trout successfully in a stream which in a dry time was hardly larger than a lead pencil, but his pond was beneath his hatchery and was completely shaded. Naturally he bred but few trout, but he demonstrated what could be done. Then Green, Stone, myself and others started at the work.

WATER SUPPLY.

Upon the volume and temperature of the water depends the success of the venture in trout breeding. That taken from near the fountain-head is best for hatching purposes if it be well aerated by falling a short distance through the air, or spread out into a thin sheet as it enters the trough. By taking it from a pool, or reservoir, near the springs, we get less sediment and more even temperatures and are not disturbed by rains or thaws; and by taking from a reservoir it has a chance to get colder in winter and so retard the hatching, an advantage which we will consider under the head of hatching. A certain amount of fall to the water into the hatching house is a necessity, and it should be at least ten inches; while a foot is needed between ponds, if they are small and in a series. Select your water supply in the driest time of the year and note its temperature at 2 P. M. on the warmest day. See that no freshet can sweep down a ravine to clog your screens and carry off the results of your labor. A sudden thaw with rain on a frozen ground may destroy the work of years.

Above all do not dam a ravine and make your ponds in the bottom of it. This is the first plan which suggests itself to the man who has given no thought to the subject. There is always some fall in a ravine, and if

you put a dam across it, tap it at one side and make the ponds on that side, well guarded by a ditch, so that no surface water can get into the ponds or increase their flow.

As the "shells" of fish eggs do not contain lime, soft water is as good as hard for their culture.

THE POLLUTION OF WATERS.

Ordinary house sewage does not seem to affect fish either in health or flavor. The Hudson River is one vast sewer for such large cities as Troy, Albany, Hudson, Poughkeepsie, Newburg, Sing Sing, Peekskill, Yonkers and New York, as well as of hundreds of smaller places, yet the shad and salmon run to the dam at Troy and are as healthy and fine flavored there as those caught below. It is difficult to poison a great river like the Hudson. I don't mean to say that these fish would live in the sewers; far from it; but the fact is that the sewage comes in at the sides of the river, is soon diluted, precipitated and rendered harmless. This is not the case with many chemicals, nor with sawdust.

Sawdust. There is a popular idea that sawdust kills off the trout in a stream by clogging the gills of the fish. Such a thing might have happened, but a trout is not killed by sand in its gills. The great harm that sawdust does is by smothering the spawning beds, more or less, and in impregnating the water with turpentine from pine and tannin from oak, which destroy the trout while in the egg. See the chapter on hatching troughs and the impossibility of hatching trout in troughs of raw, new wood.

Chemicals of many kinds will kill any and all fish if

they run into them. Lime from paper mills, the chloride, I believe, used for bleaching, is deadly on the side of the river in which it flows. The paper mills which make their stock from wood pulp do not use one-tenth the lime for bleaching which the other mills require.

The Massachusetts Commissioners of Fisheries, in their report for 1866, say:

"To state in a comprehensive way what is the effect of certain impurities in water, is by no means easy. Even supposing the mixtures thus made (refuse from factories) to be constant and stable (which they are *not*), their effect upon different animal and vegetable organisms would be quite variable. Chemical analysis is no such great helper in the difficulty as might be supposed. A science that is still so imperfect as to call starch and sugar the same thing, and that cannot tell a good wine from bad, is hardly a reliable support in testing the fine questions of animal likes and dislikes. . . . The sole way, therefore, of arriving at any result is, to make a great number of experiments upon the animals, and under the conditions required. To make such a series of experiments did not lie within the power of the Commissioners, but, to establish some main facts, a few cases were tested, as follows:

EXPERIMENT A. A young bream (*Pomotis vulgaris*) put in a glass of water, to which 1-200 in bulk of sulphuric acid was added, died in four minutes.

EXPERIMENT B. The same species, in a similar glass of water, to which 1-100 in bulk of concentrated solution of soap was added, died in two minutes.

EXPERIMENT C. A young shiner (*Leuciscus crysoleucas*) in a glass of water, to which 1-500 in bulk of chloride of lime was added, was distressed, but did not die for seven minutes.

Experiment D. A full grown shad (*Alosa præstabilis*) in a large tub of water, to which 1-400 in bulk of sulphuric acid was added, died almost immediately.

Experiment E. A similar fish, in a tub of water, to which 1-200 of concentrated solution of soap was added, became uneasy, and turned several times on its side, but at the end of five minutes was still alive and tolerably active. Compare the effect of soap on the bream.

Experiment F. A similar fish, in a tub of water, to which 1-200 in bulk of dry chloride of lime was added, became violently excited, then exhausted, and at the end of three minutes from the beginning, died from a rupture of the gill vessels.

"In these experiments large proportions of the poisons were used, in order to show plainly the effect of each. What the effects would have been on salmon we cannot infer, except that we know, in general, that the trouts are more fastidious than fish like the shad, and are more easily destroyed. A shovelful of powdered quicklime thrown on the water over a shoal of trout, will bring a number of them dead to the surface within ten minutes. Many trout brooks in England have been depopulated by drains from copper mines emptying into them; the insoluble sulphurets sink to the bottom of the brook, where they decompose, giving off free sulphuric acid, which is very destructive. Sawdust is notoriously pernicious. Its effect is mechanical, by getting into the gills and producing suffocation. Lime is as deadly to salmon as to trout; gas-works, too, are bad, and the arseniates thrown out from dye-houses are highly injurious. City sewage, unless in great quantities, will not drive them away, as is shown by salmon going up the Dee, and past the city of Chester, whose sewers empty into the river. The effect of gas-works depends,

perhaps, on the details of the manufacture. In great cities, where gas is made in large quantities, the secondary products of the distillation, such as tar, coal oils, ammonia, etc., are saved and sold. But in small towns these products are allowed to run off in a drain, and are then very deleterious to fish. The Lawrence gas-house is reputed to have destroyed a shad fishery hard by, and that opposite Holyoke is said to have driven the small fish from the neighborhood. Whereas the dock into which empties the drain of the Boston north-end gas-works, is noted as a good place to catch smelts (Osmerus viridescens)."

The Commissioners then, thirty-three years ago, believed in the theory that the effect of sawdust on trout is mechanical, a belief which I do not share. In the report of the Ohio Fish Commission for 1873 they say:

"Deleterious substances prevent the increase of fishes. The habit of throwing all the offal and waste material from factories into the river, not only prevents the increase, but actually destroys myriads of fishes annually. The waste discharged into the river from distilleries often destroys millions of fish; the waste discharges from paper mills consist of lime and other alkalies; from woolen mills the waste is mostly refuse dye stuffs, containing acids in various chemical combinations; from tanneries, acids, etc. The gas tar from gas establishments, while not absolutely poisonous, most effectually destroys the flavor of the fish and unfits them for table use. The gas works in the city of Columbus discharges the gas tar into the Scioto. What effect this has up on 'scale' fish we do not know, not having heard any complaint from the fishermen. During the winter of 1872-73, a large quantity of cat-fish were observed stranded on the 'riffles' several miles south of the city.

A Mr. Fisher picked up a 'two-horse load' of them and brought them into the city, and sold them within a very few hours. When cooked and brought upon the table they were found to be exceedingly unpalatable, tasting and smelling as though they had been thoroughly saturated with coal tar."

Under the head of "Sewerage Reform" the New York *Tribune* lately said:

"We have had occasion now and then to comment upon and to commend the action of the Connecticut courts in awarding damages to persons who complained that their use of brooks and rivers had been prevented or impaired by the pollution of those streams with sewage. Sentences have been passed, if we remember correctly, upon several individuals or corporations, and upon at least one municipality, for such pollution, and various other concerns and places have been impelled to mend their ways. All this was, as we have hitherto said, exceedingly gratifying. We believe that a similar spirit of self-defence on the part of aggrieved persons the land over would work a veritable revolution in behalf of health and cleanliness.

"But Connecticut has not been content with that. A State Commission was appointed to investigate the subject and report thereon. It has done so, and its report is instructive and suggestive. It states that all the towns and cities of the State which have sewer systems, excepting four or five, discharge their sewage into running streams or tidal harbors. The results are that the water is contaminated, the health of the people endangered, fish are destroyed, ice is made unfit for use, streams are made unsightly, and serious loss is inflicted upon the owners of riparian lands. All that was known pretty well before. It has been urged by the *Tribune*

for years, in season and out of season. It is, however, gratifying to have it formally and in detail affirmed by official authority.

"The Commission does more than merely to report. It makes recommendations. One of these is that the pouring of foul sewage into streams be absolutely forbidden by law, and another is that all cities and towns be similarly compelled to purify their sewage, in accordance with State rules and to a State standard. Those are both perfectly reasonable and sound, and it is to be hoped they will speedily be enacted into law. Then, we have no doubt, the law will be enforced, as they have a habit of doing in Connecticut, and what is now an abominable nuisance will be abated.

"The same evils exist elsewhere. They are due to the same causes. They ought to be dealt with in the same way. The same law that governs Piper's Brook should be applied to the Passaic River and to every river and brook in the land. There is no more precious gift of nature than pure water. It is abundantly given in this part of the world in springs and streams. It is intolerable that men should defile and destroy it simply through laziness or shiftlessness or through pecuniary meanness. Every community and every individual establishment should be compelled to dispose of its unclean refuse in a manner not injurious to its neighbors. Connecticut is proceeding on exactly the right lines. It would be a blessed good thing if every other State in the Union would follow her example."

The time has come when manufacturers, whether of lumber, paper, coal-oil or other things which are injurious to fish, should be required to take care of their refuse. It may cost them something, but that is no concern of ours, who believe that the rights of the public

should be considered before the convenience of a few manufacturers.

A WORD ABOUT TROUT.

As there are "many men of many minds," so there are many trouts of many kinds, and I use the word "trouts" in the plural because they are entitled to be so spoken of. On the Atlantic coast of America we have the native brook and lake trouts and the introduced brown trout of Europe, the rainbow trout and the "cut-throat trout" from the West, the latter so called from a red mark on its throat; while on the Pacific slope there is a number of trouts: two species discovered by Admiral Beardslee last year—but I might get in a muddle if I tried to name them all.

To begin with, our brook and lake trout, the latter miscalled "salmon trout," are not trout at all. Some twenty years or more ago when we sent our revered brook trout to England, our American anglers were indignant at being told that it was not a trout but a char. They had never heard of a char and within a year or so afterward, when they had learned that a char was a higher form of trout, with finer scales and requiring colder water, they cooled down and accepted the dictum of the anglers and scientists who live on the other side of the great damp spot.

The fact is that the true trouts have the dentition of the salmon and comparatively coarse scales. The brown trout, rainbow trout, and probably all the black-spotted trout of the Pacific coast are true trouts, and are included in the genus *Salmo,* while our two eastern brook and lake species and the red-spotted "Dolly Varden" trout of the West are chars and in the genus *Salvelinus,*

which is Germanized latin for "little salmon." A name is not a little thing, even if a rose by any other name would smell as sweet. We should have only one name for one fish, but with our great wealth of fishes I know of but three which bear the same name from Maine to California and from Minnesota to Texas, and those are the eel, the shad and the sturgeon.

There is a fish in England known as a salmon-trout. There is no fish in America of that species and consequently none entitled to the name. The lake trout is miscalled "salmon trout" in the Adirondacks, and, worse yet, the last part of the name is dropped and the fish is called "salmon." This is almost as much of a barbarism as applying the name "salmon" to the pike-perch in the Susquehanna, and "trout" to the black bass in the South.

The lake trout, properly so called, is known as "lunge," "togue," and perhaps by other names in New England, from Maine to Connecticut, but those names will die out in time. What is here said of trout breeding will be applicable for brook trout, rainbow and brown trout, lake trout and salmon. The other *Salmonidæ*, whitefish, smelts, etc., will be treated of under the proper headings.

HOW NATURE DOES IT.

As soon as the waters begin to feel the first chill of autumn some trout leave the deeper waters and start up stream to find the gravel beds. Usually the males are at the spawning place a week or more in advance of the females, for pairing has not yet taken place. Something tells the young trout of last spring's hatch, which will

not breed until another year, to go to the spawning grounds also, to feed upon that most delicious piscine delicacy, the eggs of trout.

When the females arrive the pairing begins, and our male char, which we have always called a trout, and always will, although we know better but have a love for the name, in his full war paint, his belly now nearly black, with bright crimson on his lower sides and his back beginning to change from olive green to buff, his lower jaw—if he is over two years old—with a fleshy tip which prevents his mouth from entirely closing, is now ready to do battle with any rival. The use of the hooked lower jaw of the male trout and salmon is not fully understood. Some one has said that it was for grasping the female in order to help her to extrude the eggs, but he does no such thing. Many days I have lain on the loose boards covering the spawning races of my trout ponds in western New York in order to see the spawn actually cast and impregnated, and I watched one pair of trout eleven mornings before my curiosity was gratified, and I afterward saw the operation four times without such weary watching, for I knew that courtship and nest-making preceded spawning by many days. In no case did the male assist her delivery in any way.

This is what I saw. The female seemed indifferent to the attentions of her mate. He chose her and drove off all others, fighting savagely at times and biting the sides of his rivals so that the scratches of his teeth could be seen, and several males died from the fungus which attacked the wounds. He would not allow another female to come too near the nest. He took no part in making the nest, but kept his place in the stream by her side when she was quiet, usually with his head alongside her

middle. Suddenly she would start, turn on her side and whip the gravel with her tail until her exertions moved her forward of the nest, and in this way a clean spot was made a foot in diameter and about five inches deep. After each sweeping of the gravel, and at other times, her mate would move forward and rub his side against her nose, all the time quivering with excitement. After several days of nest-making, the moment came—she bent her body into the nest and seemed to rub forward on the gravel, and discharged some eggs. He was at her side and fertilized them at the moment. I could plainly see the milt. Young trout got the scent of the eggs and crowded up to feast on them, but the old fellow was on guard, while she whipped some gravel over her treasures. Some two hours later the same pair repeated the performance and deposited more eggs, but I watched them the next morning without seeing more spawning and do not know whether she laid all her eggs in two batches or not. The nest was covered up and the fish remained about it for two or three days.

When this takes place in a stream, the eggs are imperfectly covered. The mother cannot see that some eggs are fanned away by the action of her tail. Another pair of trout may come and choose the same spot for a nest and whip the eggs out, to be devoured by the yearling trout, chubs, dace or other fishes, for the spawning season is from October to March. A freshet may come and smother the eggs with sediment; ducks, eels and rats will dig in the gravel for them, and fungus from a few dead eggs may kill the lot. Nature provides for this loss by giving the trout many eggs, not as many as most fishes have, but enough to keep up the stock under favorable circumstances, so that if each pair succeed in having a pair reach maturity it is all that na-

ture requires. In such an operation as I have described not over ten per cent. of the eggs are fertilized, because the milt fails to reach them, and not two per cent. hatch and live until they are ready to take food.

We beat nature in hatching fish as we do in growing corn or cotton. We impregnate 95 per cent. of the eggs and raise about 80 per cent. of the hatch, because we protect both eggs and young from all enemies.

In order to make up for infant mortality the cod, the eel and some other fishes lay many millions of eggs, seemingly to provide food for other aquatic life, just as plants provide seeds for birds and mice and still enough escape to keep up the species. The fewer the casualties to which a race is exposed the smaller the number of eggs or young which it needs to produce in order to cover the necessary losses. In fish generally it takes at least a hundred thousand eggs each year to keep up the average of the species. In frogs and other amphibians, a few hundred are amply sufficient. Reptiles often lay only a much smaller number. In birds, which hatch their own eggs and feed their young, from ten to two eggs per annum are quite sufficient to replenish the earth. Among mammals, three or four at a birth is a rare number, and many of the larger sorts produce one calf or foal at a time only. In the human race at large, a total of five or six children for each married couple during a whole lifetime makes up sufficiently for infant mortality and all other sources of loss, though among utter savages a far higher rate is usually necessary.

EGGS OF TROUT.

Eggs of the trout are comparatively few in number and of large size. They vary more than the eggs of any

fish that I know of, ranging from five to ten to the linear inch, which would make a difference of from 125 to 1,000 in a cubic inch if they could be arranged in layers; but as they would lie closer, like shot, the difference would be greater. To get the number of eggs taken from several trout it was my custom to measure one ounce in a graduating glass and count them and then measure the rest and multiply. A trout will spawn at 18 months old; it may then be from four to ten inches long and its eggs will be in proportion and vary from fifty to a hundred or more. A year later it may yield over a thousand, dependent on its growth and condition. I have taken nearly 5,000 eggs from a trout which might have weighed four pounds, so that the old formula of "a thousand eggs to the pound" is not a rule. From a four-pound codfish I should expect 400,000 eggs. The small eggs naturally produce small fish, but abnormally large eggs do not seem to produce any better fish than those of moderate size. For good, strong fry a trout at its second spawning, when two and a half years old, is my choice, and I would never voluntarily keep a trout above that age. I say "voluntarily" because when in charge of a State hatchery the Commissioners and the people wanted to see big trout, and I had them up to five pounds, and over, but they were of little use as breeders and ate their heads off every month, and their eggs were almost worthless.

MARKETABLE TROUT.

There is another reason why I would not keep any trout after it had spawned the second time and recovered the next spring, and that is this: It is too big for

market. An angler likes to capture a big trout to show, but he prefers to eat the smaller ones. Many years of attendance at Blackford's annual "trout openings" in Fulton Market on the first day of the legal trout season has shown that the desirable sizes are from three to five to the pound. These are fried or boiled with the head left on and are served whole to a guest. If a little larger they would have to be cut and served in portions, while those over two pounds should be boiled; and that is not what the epicure wants, because if his fish is to be boiled he would prefer cod, salmon, lake trout or many other fishes, for the idea of having brook trout served otherwise than fried or broiled never occurs to him, and he likes them whole.

For some years Mr. Gilbert, of the Old Colony Trout Ponds, and Mr. Hoxsie, of Rhode Island, have agitated the question of selling the trout raised by breeders at such season as they may choose. In the report of the American Fisheries Society for 1895, page 80, Mr. Hoxsie said: " . . . Is there not some way in which the man who makes a business of raising trout, for what little money there is in it, can be allowed to ship them into New York to the market whenever they are fit for it? The law seems a little unjust. If I were in Rhode Island and raised chickens and turkeys I could send them at any time, but cannot send trout to New York, it being the market for what I produce. One year New York passed a law that we should not get fish [there] until the first day of May. I am not doing a large business, but that year we did not pay our expenses by about $1,500. We have shipped already this season over six tons of brook trout. The price has been low, but we cannot govern that if we don't get fish there until April 16th. I would rather have February, March

and April; I can then sell all I can raise, but later in the season people have gone out of town for the summer."

Hon. Herschel Whitaker, of the Michigan Fish Commission, voiced the sentiment of those present when he said: "A close season for fish is for their protection during the period of reproduction, and that is the only interpretation to be given to it. It may work hardship for those engaged in raising and selling fish, if the law precludes them from following their occupation. It is to the interest of the whole people that the close season should be established for the protection of fish during the season of reproduction, and the interest of the individual should be subservient to the larger interest."

I agree with Mr. Whitaker. I am a fishculturist by profession and an angler from choice. The opening of our markets to pond-bred trout would open the gates to all the poachers of trout streams in the country, and it would be impossible to keep their illegal catch from the markets. The raising of chickens and turkeys is not a parallel case, for they do not exist in a wild state in the East.

I have listened to these arguments year after year, but have taken little part in them. Here are my heretical views: The brook trout ranks as a first-class table fish in cities removed from the salt water. In New York, Boston and other seaboard cities it has a sentimental value and sells for 30 cents to $1 per pound. The sale is mainly to city anglers who fish for the trout at the opening season, if they can get away, and who buy the fish to revive old camp memories more than anything else. They have them cooked at the club or take them home and try to make their wives enthuse over them, just as I buy venison chops every year and

recall camp scenes without getting my family to enjoy them as I do. I don't believe that any amount of trout worth considering could be sold in New York a week before the legal opening, for reasons given above.

As I have said, the demand for brook trout in seaboard cities is largely a sentimental one, based on the long trip into the wilderness, the return to the half-savage life of primitive man and the appetite which comes from a day's tramp, when trout must be cleaned and cooked before the hungry angler eats; and then he remembers a fish that is half raw and half burned as one of the greatest delicacies which ever came his way. In his club or cafe, when his appetite was clamorous for something, no matter what—when he could eat a mule and chase the rider—he would send the fish back to the kitchen; if he wishes to eat trout he wants it properly cooked—when he is in the city.

I am not an iconoclast. On the contrary, it is my nature to be a hero worshiper, but the statements made above are what I believe, and I will venture to incur the wrath of the angler who takes his trout in the rushing waters of the brook by saying: It is the fashion, my dear brother—and I can say with Walton, "I am, sir, a brother of the angle"—for you to decry all pond, or liver-fed trout, as unfit to eat. This entirely accords with what I have said before, and is just what you might be expected to do; but as Prince Hal says to Falstaff: "Mark how plain a tale shall put you down." During the years that I have attended Blackford's trout openings I have eaten trout from many places, wild and liver fed, and as they were marked by mutilations of the caudal fin it was interesting to hear the comments of the dozen or more anglers each year.

It is my opinion that a plump liver-fed trout is the

equal of any other trout for the table. I like an occasional breakfast of calve's liver and bacon, and why is not good, tender beef liver as good for a trout? Why is not a diet of liver as good as worms, snails, bugs, caterpillars, mice and small trout? This, as I have said, is sentiment, pure and simple. It is the romance that the angler weaves about his beautiful fish which he traveled miles for and worked hard to get after he got there. Divested of this sentiment there would be no fancy prices for brook trout. It would take its place in the markets with other food fishes and would drop behind some of them. As an angler's fish it is a noble one, and it is one of the best of fresh water fishes for the table, if it is not muddy.

When a boy the perch, bullheads and suckers from the mill pond seemed to be the best of fishes, and I did not understand why some people turned up their noses at them and preferred the fish of salt water. That knowledge came later, and outside of the whitefish of the great lakes, and its relatives, there is no fresh water fish that I care to buy more than once a year. "If this be treason, make the most of it."

In camp I declare that the brook trout just now fried with salt pork, or roasted before the fire, are the finest fish that ever went down my œsophagus, but when I am only half hungry in a New York cafe there is a change of opinion.

Yet, after writing this, there is a remembrance of camp life that crops up "like the faint, exquisite music of a dream," and a memory of trout fried in bear fat is enjoyed for a moment and is followed by the greatest treat of my life as memory harks back to some plump trout cooked in beaver fat with a beaver's tail frying among them. That was a dish to be remembered, and

the greater the lapse of time the more distinct is the memory.

CHAPTER II.

IN THE HATCHING HOUSE.

Trout can be hatched without a house, but not as well as in one. Eggs may be procured and put in the gravel of a spring or of a running stream—in "redds," as nests are called across the water—but the dangers they meet there have been told, and not one in fifty will become a trout. They may be hatched in covered troughs which have graveled bottoms, but frost may interfere with the level or may stop the water supply; inquisitive persons may replace the covers carelessly and let in sunshine, or other things may interfere with the success of the venture. By all means do your hatching under a roof if you wish to succeed.

A house 20x30 feet will contain 12 troughs, placed by twos, with a single one at each end, and in single layers of eggs will have a capacity of 300,000 eggs which can be hatched and the fry fed in the troughs for a month or more. The capacity can be increased four or five times, but the fry must be removed before feeding. The house should have a cupola or an airshaft at the top to carry off the vapor, which would otherwise condense on the walls and windows. Brick walls will absorb moisture, freeze and crumble, and a lining of yellow pine ceiling with the same material for the floor is best because it swells less than other available woods,

and a coat of spar varnish makes it bright and attractive. When I began operations at Cold Spring Harbor, N. Y., in January, 1883, I had an old brick house, 20x30, on the hill; the water from there went into an old tumble-down wooden building of the same size and water from a lower reservoir, and it was practically a fed troughs on the upper floor, while below we took three-story hatchery. Then, when the brown trout eggs came from Germany I had to put troughs outdoors and give them water from the lower floor. It was all hastily improvised, for there had been no time to prepare for the work; but I had then fifteen years' experience and knew how to care for the eggs until troughs and trays could be made.

Salmon eggs came in crates from Maine, trout eggs from Caledonia, N. Y., and from Germany, which taxed the new hatchery beyond its capacity; but I brought over a lot of poor troughs from Roslyn, made under like conditions the winter before for salmon work, and had more made. The only eggs which were injured by this imperfect preparation were some that were in the outdoor trough, where frost and visitors interfered. One night the frost choked the outlets on the upper floor of the wooden building and the water overflowed the troughs and froze two feet thick on the outside of the building, so that we had to chop the ice to open the door. The eggs were heavy and received no damage, but it was fortunate that the water supply was not stopped.

The hatchery may be an inexpensive shed, but the floor should be solidly supported, so that there is no jar to the troughs when people walk about. Windows should be plenty, but provided with heavy roller shades, preferably of a green color, so that light may be had

from all sides except when the sun may shine directly on the troughs or eggs. If this is not practicable then make covers for the troughs; these may be hinged so as to lie over on the adjoining trough.

Good, clear white pine is the best material for troughs, if free from sap and knots. It swells tight and the nails can be set up, if needed. I have used yellow pine, but it is hard and unyielding and is more difficult to make tight because it does not swell, yet it is more lasting than white pine. A trough of the latter is good for from four to eight years, and then soft spots of sap, or heart, begin to show; a patch or two of one-half inch pine is let in, embedded in coal tar, and it goes for a year or two more. Troughs of yellow pine made in 1886 are good as ever twelve years later, yet they are unhandy to tack screen strips in and more so to pull a brad from. Where these woods cannot be obtained some native wood must be substituted. White cedar would be an ideal wood, if it grew large enough.

A distributing trough running across the head of a series of hatching troughs has been the regulation mode of supply in hatcheries since they have existed, and the practical worker knows what a nuisance they are. Running the length of the building, the least settling opens the joints, and their length forbids their being moved after having been built in position. Then a bit of sapwood or heart in some spot will decay, and the whole trough will be condemned and a new one made. The life of such a trough may be from four to ten years, but it is always under suspicion of leaking at any time. I had one 60 feet long that lasted eight years, but was calked and pitched many times, and I thought of lining it with sheet lead of about three pounds per square foot and then replace the wood piece by piece, as needed.

Watch the carpenter at every point in the making of troughs, and especially in the selection of the planks. If a bottom plank has a bit of sap-wood on the corner of one edge, have it put on the downward side, where it does not come in contact with water. If a side plank has a strip of sap-wood, have him put that edge on top, above water, for such parts are the first to decay. The hearts of the tree are next in order to rot, and if there is a heart-streak in a plank have it on the outside.

See that the edges of the bottom planks are not only all of a width, but that they are absolutely straight and the edges perfectly square. If the planks are $1\frac{1}{2}$ inches thick use twenty-penny nails, wire-nails, and these are $4\frac{1}{2}$ inches long. Have him put the nails $2\frac{1}{2}$ inches apart, and not in a straight row, but alternately up and down in order to prevent splitting the planks.

These things may seem unimportant details, but they are worth attending to if one cares to have the troughs not only water-tight but also to last as many years as possible.

It has been my custom to take a pair of compasses and mark on the lower end of each trough the year in which it was made. On the first trough in the frontispiece may be seen the figures 1888, so made. This enables one to know just how long that trough has lived, and to judge of the defects of certain planks. It is a record that may be wished for in later years.

The question of painting or tarring the outside of troughs may be a debatable one. The troughs look better for it, but I incline to think that it retains the moisture in the wood, and so helps to rot it. But, above all, have the troughs tight.

Of course a slovenly superintendent who is content to have leaky troughs, a wet floor, and to slosh around in rubber boots, cares nothing for a leak here and there, any more than he does to see men spit on the floor of his hatchery, and it is not for him that this is written.

The subject of dry and clean floors interested me years ago, and still does. My floor at Cold Spring Harbor is clean, but a trough that leaks a few drops, just enough to show, is an annoyance. I was called to plan a hatchery at Bath, Steuben county, N. Y., for the State in 1894. I arranged for a row of troughs on each side of the building, with a six-foot aisle in the middle at the foot of each series. The troughs were arranged by twos, for I would not have them in threes unless the lot was too small to expand the hatchery to the required capacity; and as the water was to be brought in a six-inch iron pipe for some 600 feet, with a fall of about 10 feet to the hatchery floor, my old ideas naturally ran to having the pipe branch above the building and flow into two distributing troughs, one on each side, and to discharge from the hatching troughs under the floor. I had long used brass gate-valves in wooden supply troughs, and as there were to be 18 troughs on each side I finally decided that the following sketch would be an improvement on any method yet devised, and I made a plan which I hoped to introduce, but the Commissioners got into a dispute and another man finished the work.

The following are the advantages of this mode of supply:

1. Absolute control of the supply without a drip when shut down.

2. Saving a portion of the space occupied by the supply trough.

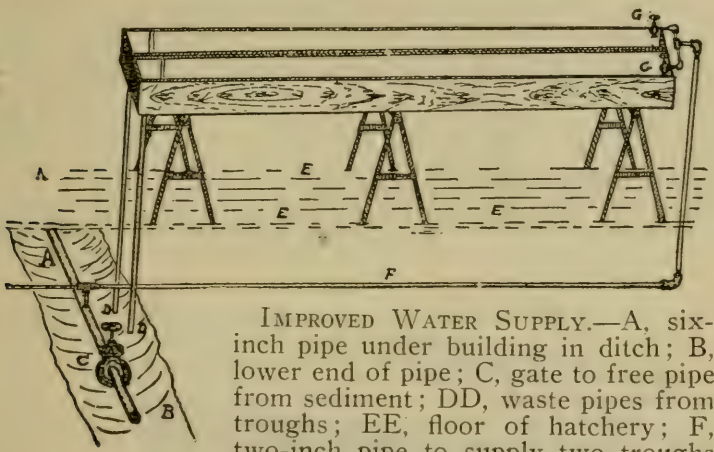
3. The ease of cleaning the main pipe A by the full-

sized gate, which when shut entirely down causes water not used in the troughs to flow over the upper dam into the ponds.

4. Discharging in a central ditch under the floor.

5. Cheapness in construction and lasting a hundred times as long as wooden distributing troughs.

At the Long Island station I ran the waste water back under the hatching troughs in four-inch soil pipes to a waste trough outside the building (see frontispiece), because the ground under the hatchery is lower than



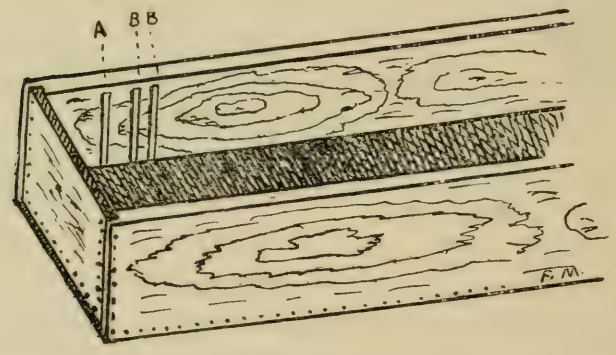
IMPROVED WATER SUPPLY.—A, six-inch pipe under building in ditch; B, lower end of pipe; C, gate to free pipe from sediment; DD, waste pipes from troughs; EE, floor of hatchery; F, two-inch pipe to supply two troughs on each side of the house; GG, brass gates, 1 1-4 inch, which is plenty, with a 10-foot head.

the ponds outside, but at Bath the case is different and the arrangement shown is the best for the situation, and as it is a different mode of supply from any in use as far as I know, it seems worthy of illustration.

The main pipe was to be pierced for nine two-inch uprights with "tees" to branch to each side, under the floor; these will bend up and over the troughs, ending in a "tee" with two branches and gates, which, with a head of several feet, will give the required flow.

HATCHING TROUGHS should be made with great care I prefer 1½-inch plank, dressed both sides, which leaves it over an inch in thickness. Have your carpenter get out the bottoms of the best stuff and of an exact width to a hair. This will allow screens, dams and trays to fit all the troughs, and you will have a standard size for them. Insist on this. Never nail the bottoms to the sides; it takes wider bottoms, and is the wrong way to do it. My favorite size for a hatching trough is 14 feet long, 14 inches wide and eight inches deep, inside measure. If of 1½-inch stuff the side planks are 9½ inches wide. Lay in white lead or thick coal tar. If in white lead do not let it come to the surface of the bottom plank, for coal tar will not dry over it. Rabbet the ends in the bottom and sides, as shown in the cut, and you can nail both ways and make tight ends.

When the troughs are made and dry coat them with



END OF TROUGH.

coal tar from the gas works, thinned with spirits of turpentine. Have it so thin that it will strike in and dry in 24 hours, in summer. Use a half-worn paint brush, and when dry give it a second and a third coat. Be sure that it is thin enough to be absorbed by the wood and

not left as a coat of paint. After four coats the grain of the wood should show. A trough should be thus coated every summer during its life, but beware of putting it on thick, like paint. After a few coats there will be a gloss, but the object is to have the varnish strike into the wood. Coat all your woodwork and wire screens, dams, etc., in the hatchery, wherever water touches, with the thinned coal tar. Many fishculturists use an asphalt varnish. It is as good as coal tar, but while I have seen troughs coated with it, I never saw it applied. A barrel of coal tar, or gas tar—it's the same—would cost less than $2, freight and all, and last for five years. It is so good that I never experimented in any other direction. The top of the trough should be three feet four inches to three feet seven inches from the floor, according to the height of the workers, so that they may not stoop at their work.

TROUGH FOR YOUNG SALMONIDÆ.

In *Forest and Stream* of Feb. 19, 1891, Mr. William P. Seal makes a good suggestion. He says: "The idea which has suggested itself to the writer as a result of observation, though not of practical experience, is a double trough, or trough inside a trough, as shown in the accompanying sketch. One bottom answers for both, of course. Along the sides of the inside trough are arranged a series of angular chambers, made by placing pieces of wood or metal of a required size at an angle from the sides, and covering the mouth or base of the angle with wire gauze, letting the wood project some little distance beyond the gauze, as shown in the sketch.

"Now, entering into each of these angles from the outer trough is a hole with a gate, by which the flow of water may be regulated. * * * The idea is to introduce currents of water at intervals along the entire length of the trough in such a way that the fish

Trough for Young Salmon.

will find a number of places with the conditions they prefer, instead of the single one at the head of the ordinary trough. * * *."

Mr. Seal gives no explanation of the letters used in the diagram. As I understand it they are as follows: BB, troughs; F, wood or metal angles; W, wire gauze. If the inner trough could be made to sit so flat on the bottom that no little heads could wedge under it, this plan would be good. There is no record of the use of such a trough.

WHY DO WE USE COAL TAR?

That is a very proper question, and to answer it I will have to tell a story. Raw white pine troughs put in the hatchery and fed with water soon begin to exude a jelly. I have taken sheets of it from the bottom and sides that were ¼ of an inch thick. This is a form of turpentine, and it will kill trout eggs and embryo trout, every one of them. When I visited the Caledonia hatchery in the spring of 1868, the troughs were lined with 10x12 win-

dow glass laid in white lead, and there were trout eggs on gravel laid on the glass. The swelling of the trough left patches of bare pine and there the jelly asserted itself. I tried it with the same result, and lost many eggs.

Mr. Livingston Stone obtained a patent for a trough of charred wood, June 20, 1871. This solved the problem, for fungus will not grow on charcoal, and in an emergency, in January, 1882—when Prof. Baird sent me a lot of salmon eggs to hatch for the Hudson, and I hustled around and got Thomas Chapham's disused hatchery at Roslyn, Long Island—I had a lot of cheap troughs made and the weather was too cold for the tar to dry and started in. The eggs were far advanced and began to hatch in the spring water, which was warmer than the air; for I had kept the eggs in the packages just above the freezing point. The first lot showed the disease which we know as "blue-belly," and I saw that the wood was too raw. I took trough after trough, dried them, filled them with straw and coal tar, set them on end to make a chimney and charred them deeply. It was a success; the remaining salmon did well, but the charcoal was dirty to the hands.

A year or more later I read somewhere of the use of coal tar for troughs and tried it. It was perfect, but the name of the man who suggested it is not known to me. I think he was a Frenchman. Of course, Seth Green claimed to know all about it, for Seth had a way of discounting all discoveries, as he did in the case of dry impregnation, which we will come to later.

The coal tar should be thoroughly dried before water touches it, for it will not harden under water, nor over paint nor white lead. With three thin coats there will be no more flavor of tar to the water in the trough than

if it was in glass. Asphalt varnish is equally good, as I have seen, but coal tar was always so handy and so perfectly satisfactory that I never used anything else.

Coat all troughs, trays and everything which comes in contact with the water every summer and they will last long and be sweet and clean.

HATCHING TRAYS.

These should be made ½ inch narrower than the troughs. Make them of ¾x½ inch stuff, to lie flat—*i. e.*, the half-inch to be the depth. Heavier wood will float the trays. Halve the corners so that they can be nailed both ways, and make the length as you wish. A 14-foot trough wants about six inches for the water to spend its downward force in, and as much for the lower dam. Seven screens of 22 inches each, outside measure, will be plenty for a trough of that length.

Have your wire-cloth for the trays especially woven. As the trays will be 13½ inches wide and the selvege will be irregular, have the wire-cloth 13 inches and as long as may be needed. For trout let it be in this way: Meshes ¾ inch long by ⅛ wide, the length of the mesh to run across the trough. The warp, which runs the long way, being of fine wire, No. 24, and double, going over and under the heavier woof, or filling, of No. 18 wire. This gives us the long mesh across the trough and the eggs do not wash and bunch in the current. The embryo fish will then drop through the meshes. Put the wire-cloth on the frames with small double-pointed tacks, and put one in each corner of the frame for a leg, in order that the water may flow under the tray, as well as over it.

New wire-cloth does not take tar readily; put it alternately in water and in air and slightly rust it and it will catch on at once. For the trays a well-worn paint brush is best; and I have taken new brushes, tied them down and cut them off until they were stiff enough to use on wire-cloth. Do all this work in summer, in the open air, and let it dry thoroughly before giving a second coat. Do this each year and look out for every rust spot and kill it.

Don't use copper wire for hatching. Copper will do for outlet screens for ponds, but it will kill eggs. Have nothing to do with galvanized wire unless at outlets, for the same reason. I've learned all this by experiment and give you the result without cost. The glass grilles which are used in Europe are good; nothing is cleaner than glass, but the first cost and the breakage make it objectionable. Wire trays are just as good, and much cheaper.

Some years ago, to my surprise, Mr. Frank N. Clark announced that he had gone back to the use of gravel for hatching trout. When we used gravel we sifted it so that it was not larger than the trout eggs, running through a No. 10 screen to get rid of larger pieces and then through a No. 14 to work out the sand. Even then some eggs would get into the gravel and die, grow fungus and become a nuisance, while under the gravel was a black mess full of sulphureted hydrogen which smelt to heaven when the gravel was stirred. Knowing that Mr. Clark is always sincere in all his statements —although we often disagree on some trivial point—I wrote him asking for his reasons for using gravel, at the same time telling him that I wished to publish what he said. He writes as follows:

"NORTHVILLE, MICH., Jan. 21, 1899.

"MY DEAR MATHER: I do not know how to describe to you my reasons for using gravel in handling the eggs of the Lochleven and the brook trout, other than the fact that my motive is to employ the method which will insure the largest percentage of eyed eggs, and by the use of gravel we certainly have obtained better results. We use gravel only for the eggs taken from the parent fish at this station, and then only until the eye spots appear, when they are siphoned off the gravel and placed on trays. By actual records at Northville, we have met with from 10 to 15 per cent. greater loss by placing the green eggs on wire cloth instead of on gravel. What there is about the gravel which causes a better percentage is more than I can tell. It may be due to some chemical affinity between the wire trays and the water here at Northville, producing a combination injurious to the eggs, but it is certainly not imagination. It is proven by actual records. Cordially yours,

"FRANK N. CLARK."

What Mr. Clark says about the water and the wire trays reminds me that at Cold Spring Harbor zinc-lined waste troughs would be eaten full of pinholes in one season by chemical action, while at other stations zinc lasts a long time.

PREPARING FOR HATCHING.

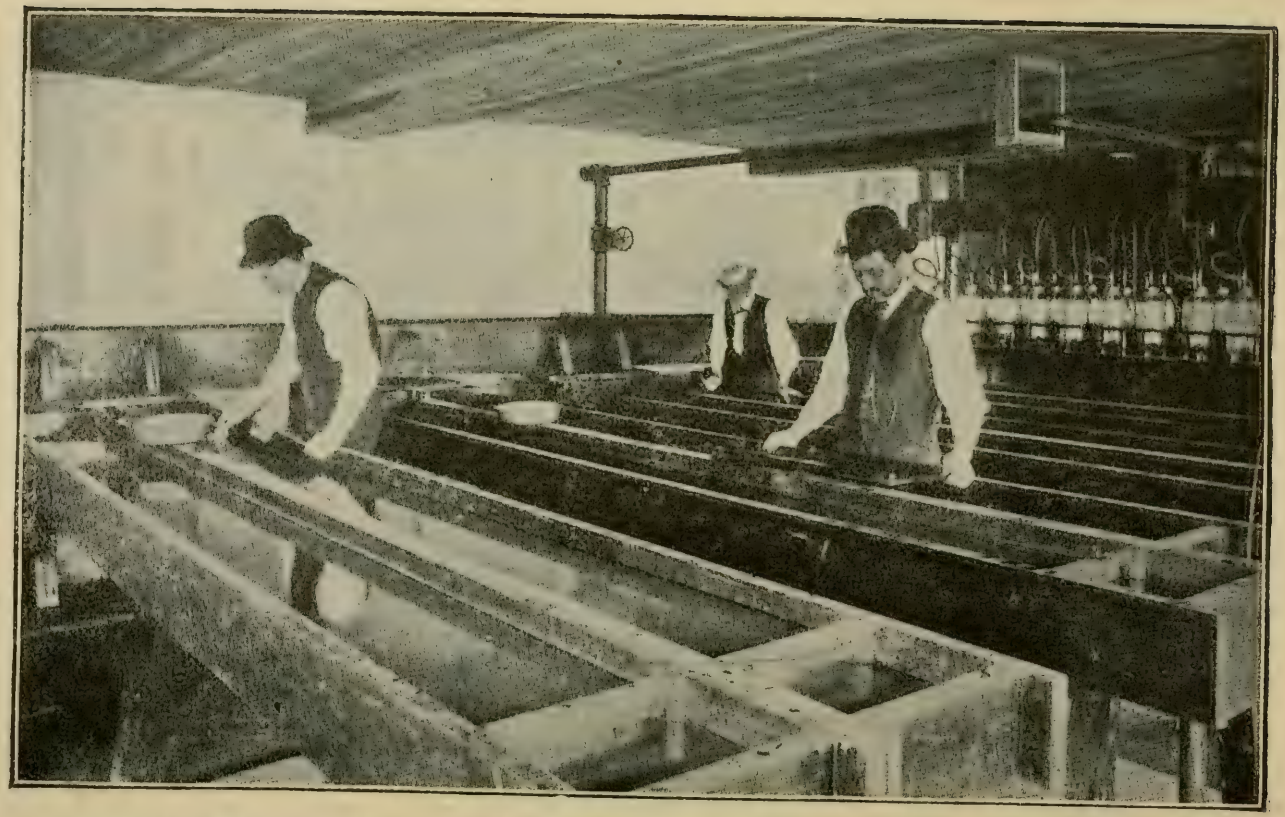
Everything should be ready and the water running through the troughs a week or two before an egg is taken. Put in a horizontal screen at the head of the trough one inch below its top. Let it be the width of the trough and about 5 inches long; lay it on cleats, or

suspend it in any other way. This is to stop all gammarus or plants, which may clog the lower screen but cannot clog this one because it is above high-water level. Gammarus are good trout food, but are not desirable in troughs, because they may kill delicate embryo trout, although they do not seem to hurt the eggs. They are scavengers, and will eat a dead embryo; but it is best for the fishculturist to be his own scavenger in the troughs.

At the lower end of the trough arrange to carry your outflow straight under the floor or back under the trough, as may be convenient; but I prefer to have the outlet hole in the bottom, and not in the end of the trough. Put a one and one-half inch "sink plug," to be obtained of a plumber, two inches from the end, first filing out the cross bars; then throw away the stopper. A short tin tube soldered to the lower end will prevent all slopping over into the pipe which takes away the water.

An inch above the hole put a one-half inch strip on the sides to hold a dam; and an inch above this put two similar strips for the outlet screen to slide in. Three small wire brads will hold the strips in place. See cut on page 46, which shows how the end of the trough is let in. Some carpenters prefer to let the sides and bottoms of troughs project an inch beyond the ends, but that is one of those minor matters of detail that are not of enough importance to argue about.

Now make your one and one-half inch dams, and also some six-inch dams to fit the same place, and mark them with a chisel with the number of the trough, for they must be water-tight on bottom and sides. The narrow dams are to be used until hatching begins, and then the deeper ones are to be put in, and the screens also. Fit



THE WYTHEVILLE (VA.) HATCHERY.—PICKING OUT THE DEAD EGGS.

From "Manual of Fishculture."

the screen tight, especially at the bottom, or heads and tails will be wedged in there, and the owners of those heads and tails will die. You will believe more of this the second season when you see how small a pinhole an embryo trout can commit suicide in. Many times I have sifted fine sand along the bottom of such a screen, to keep tails, heads and parts of sacs from getting under it.

This outlet screen may be of finely perforated tin, one-sixteenth of an inch. Mr. Frank N. Clark used this and recommended it to me, but I did not like it because in a given area the holes were the smallest part. I prefer No. 20 copper wire cloth, or, if of iron wire, to be tarred, No. 16. In wire cloth the "holes" are the largest part of the area, and they last the longest.

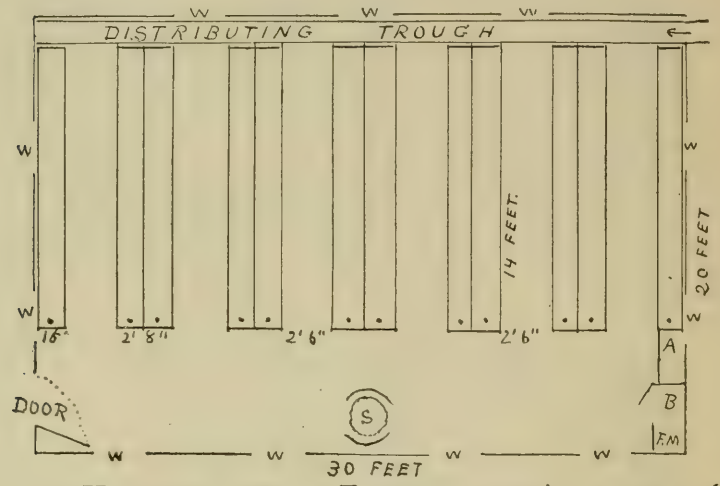
Now that all is ready in the trough, mount it on carpenter's "horses"—three, if the trough is not over fifteen feet long—and have it exactly level across the bottom, but give it at least half an inch fall in its length. This fall is merely for convenience in cleaning, nothing more.

I prefer the trays to set flat, on carpet-tack legs, as described, instead of having them raised on their "hind legs," as some others place them; but this is a minor point, not worth discussing.

Let the water run through; tighten troughs after a day or two by a nail-set and a hammer; and here is where you will learn why the sides of a trough should be nailed to the bottom, for convenience in tightening as well as for increased stiffness.

Put the hatching trays in the troughs, weight them down with stones until they cease to float, and then you may sit down, light your pipe and say: "Now bring on your eggs!"

FILTERS.—If filters are necessary they may be made in wide troughs with coarse wire screens at the upper end and finer ones below, ending in cheese-cloth or flan-



PLAN OF HATCHERY WITH 12 TROUGHS; capacity 30,000 each in single layer. A, sink for washing; B, closet; S, stove; WW, windows.

nel. Or the water may flow through sand and gravel, according to the nature of the material to be filtered out. There should be a screen at the head of each trough to prevent stoppage at the outlet.

CHAPTER III.

TROUT EGGS.—DISTINGUISHING SEX IN FISHES.

It is with the fishes as with the birds: some species show sexual differences at a glance at all times, some

only during the breeding season, and others are so nearly similar that except for the protruding abdomen of the gravid female the sex can be distinguished only by dissection.

A few, as the sharks and rays, have as distinct marks of sex, as do mammals, such as "claspers," spines on head and fins, etc.; others, as the *Embiotocoids,* or viviparous fishes, have a different structure of the anal fin, while the great majority of fishes, especially the fresh-water kinds, have merely a brilliancy or intensity of color during the pairing season, which is invariably confined to the males. There is a very common notion prevalent that goldfish can be distinguished by the dorsal fin, that of the male being shorter than that of the female—that is, having not so many rays; but this is entirely groundless. The dorsal fins of this species, *Carassius auratus,* are very variable, as in fact the entire fish is, but this variation does not indicate sex in the least, and I do not hesitate to say that this fish is one whose sex cannot be told except by dissection, save when the female is distended with eggs.

The little *Cyprinodonts,* killey fishes, show during the spring and summer such great differences between the dandy male and its quaker-like mate that they might be mistaken for different species, while most of the percoids, as perch, bass, sunfishes, etc., simply show a difference in the intensity of the colors. In some of the sticklebacks, as *Eucalia inconstans,* Jordan, the male is gorgeous in red and green during the breeding season, while the more sober bridegroom of the four-spined variety, *Apeltes quadracus,* contents himself with a small pair of crimson ventral fins. Most of the cyprinoids, at other times indistinguishable, can be recognized during the breeding season by brightly-colored fins.

The same may be said of the brook trout; but trout breeders learn to separate the sexes at other seasons by their general appearance without being able to describe exactly how. An old male trout is readily determined by its lank sides and general air of a dilapidated roue, but a vigorous male of three years old before putting on his autumnal dress is very like the female, and is only to be distinguished by a trained eye, and even then mistakes occur. It is a matter of doubt if the yearlings can be separated by sexes with anything approximating a certainty. The males of a northern sea fish closely related to the smelt, and known as the capelin, *Mallotus villosus,* are said to be provided "with a ridge of closely-set, brush-like scales, by the aid of which two males, one on each side, hold the female, while she runs with great swiftness on the sandy beach and there deposits her spawn," a clear case of polyandry, which is exceptional among fishes, which vary more in their methods of reproduction than the members of any other class. The well-known hooked lower jaw of the male Atlantic salmon, *Salmo salar,* is only a nuptial appendage, which is afterward absorbed; but in several of the Pacific species of salmon this is a permanent mark of the male, and from this feature they have received from Professors Gill and Jordan the generic name of *Oncorhynchus,* and have been removed, in their revision of the *Salmonidæ,* from the genus *Salmo.* To this genus belong the so-called "California salmon," now *O chouicha* of the new nomenclature, and four other species.

Among the strikingly formed and brilliantly colored tropical fishes there are often marked differences in the sexes, both in structure and color, and one known as the gemmeous dragonet, *Callionymous lyra,* has been described by Linnæus, and several subsequent natural-

ists, as two distinct species, as they not only differ in the size and shape of the fins and the hues of the body, but also in the proportional size of the head and mouth, and even in the position of the eyes. As has been shown, there are slight, if any, differences between the sexes of our fresh water forms, except at the breeding season, when they are manifested principally by color. There is, however, always a difference in size, for in no species with which I am familiar does the male fish ever attain the extreme bulk that the adult female does. This difference is more remarkable in some species than in others, but I do not hesitate to assert that it exists in all. In the little "Killey," referred to above, the female is twice as large as her mate, and the striped bass, or Rock, is another example; all the large ones, from forty to a hundred pounds, or more, are females. How large the male rockfish is found I cannot say, but I incline to the opinion that specimens weighing above thirty pounds are rare.

The male brook trout begins to grow a brighter red on the sides as the water cools in October, in New York, and as he ripens this becomes brilliant. Then, if not old enough to be disfigured by a pronounced hooked jaw, he is one of the most beautiful of all our fresh-water fishes. If, however, he does not find a mate, or is driven from her by a stronger fish, his unexpended force manifests itself by another change. The crimson side fades into a drab, or buff, and the flat edge of the white belly is bordered with a broad black line. Such a fish will yield milt at the slightest touch, and it is the best of all milt, for it is dead ripe. Large males, those of three or four pounds, seldom get in this state, and I don't care for them as breeders.

If I were breeding trout as a private enterprise, no

fish over three years old would be kept. That is, a fish hatched in March, 1890, would spawn in November, 1891, when twenty months old, and would give more or less eggs, according to her growth, but should be just the right size for market. A few thrifty breeders can be kept with profit another year, when they will yield three or four times the amount of eggs that they did a twelvemonth ago; but then they should go to market the next spring and make room for younger stock, for their market value is decreasing in proportion to their size, as I have shown under the head of "Marketable Trout."

TAKING TROUT EGGS.

In an old English cook-book by a Mrs. Glass, she begins telling how to cook a hare, with the words: "First catch your hare." The trout culturist in quest of eggs may follow the sage advice of Mrs. Glass. But, when the trout is caught, he must pause. Eggs are desirable, but are worthless unless they are fully ripe; and, if the eggs are not ripe, the mother will surely be killed if they are forced from her. A male fish may sometimes be ripped open and his milt teased out in water, but no such Cæsarian operation will yield young from the female trout, and in all trout work, extending over half a century, not a troutlet can say, with Macbeth, "I was from my mother's womb untimely ripped."

The trout are either netted in ponds or streams or entrapped in spawning races, which are covered gravelly runs, and will be described under the head of "Ponds." As our brook, brown, rainbow and most other trout spawn in the daytime, the early morning is

best to take the eggs of such fishes as are ready to spawn on that day, leaving all others for a future day. The lake trout, improperly called "salmon trout," *S. namaycush,* spawn at night, and as they often live in the same lakes, and sometimes have their spawning grounds in common with the brook trout, their different hours of spawning prevent hybridizing, for milt is sterile after being in water a few minutes.

In taking eggs from a covered raceway we dropped a screen at the lower end, threw off the covers and netted the fish into tubs of water for examination and assorting. The males are put together, the females that appear to be ripe go in other tubs, while those not nearly ripe are returned to the pond. The ripe female has a soft abdomen and the vent is swollen, protruding and red. Here is the delicate point: to judge the amount of pressure needed to start the eggs. Her tail is taken in the left hand and bent upward, the right hand holding the head with a grip of thumb and the three last fingers on the bony arch back of the gills; the forefinger is then free to stroke the abdomen. Often the bending of the back will start the flow of eggs; if not, then it may require several light strokes to start them; but if the trout is not fully ripe she must be kept a day or two more, for if much force is used she is apt to die, and while some of her eggs may be ripe enough to be impregnated, they will produce embryos, which will either die in the egg or live along in a feeble manner and amount to nothing, few surviving the absorption of the sac.

THE MALE TROUT in spawning time has a bright red belly and is slim in comparison. He need not be handled as carefully as his mate with her burden. The milt of one male is often sufficient for half a dozen

spawners, as a few drops are enough for the eggs of one fish.

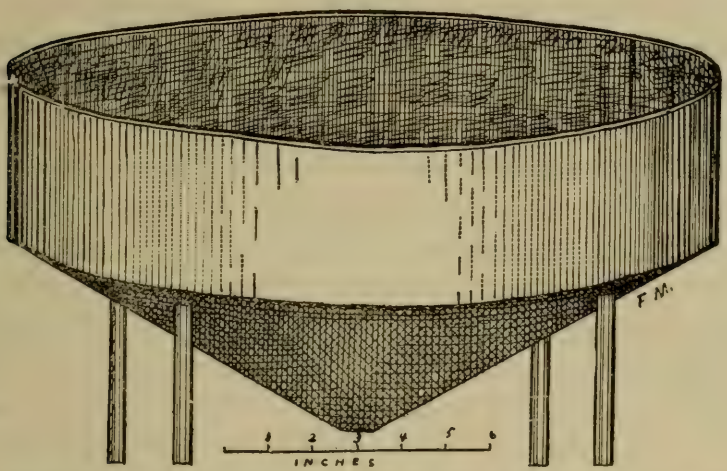
Impregnating the Eggs.—Clean pans must be used and cleanliness is essential in all fishcultural operations. Have pans for this purpose and never put anything but water and eggs in them. Tin, earthen and

Stripping a Small Trout.

enameled-iron will do, but the paper ones which I tried once in shad hatching did not produce strong fish; why, I don't know; but they were discarded. Wet the pan to free it from dust and lightly drain it; wet your hands and strip the female trout, remembering that she has an ovary on each side that reaches from vent to gills. Begin near the vent and work up gradually, and when you have finished she will look very slim. Work

as fast as possible, for she is becoming faint and may need a rest in the tub if you are too long about it. If you have a helper, let him strip a male or two at the same time, right over the eggs; if alone, strip a male and then add just water enough to cover the eggs and let them stand for a few minutes and add as much more water.

The milt of the male contains microscopic organisms called spermatozoa, which lie quiescent until they



SPAWNING FUNNEL, to strip fish in, to prevent their slipping among the eggs in pan below.

strike water, when they begin to be active, but die in three to five minutes afterward. The eggs are soft and flabby when they come from the female, because there is a loose outer coat which has a funnel-shaped orifice in it, which is called the micropyle. Through this the egg absorbs water, and if that water is heavily charged with milt a spermatozoon is likely to enter and the egg is fertilized. In twenty or thirty minutes the egg will have absorbed all it can, and if not impreg-

nated within that time no power can fertilize it. Always dilute the milt slightly with water or it will not be active. Bloody milt is not good. Here is where we beat nature by bringing every egg in contact with the milt and giving it a chance to get a spermatozoon before it has ceased absorbing.

At first the eggs adhere to the pan or to each other, because they are flabby, just as a piece of wet leather adheres to and can be made to lift a brick. They must not be disturbed until they have drunk their fill and are free, when they are washed from superfluous milt and placed on the trays. Leave them long in the pan and don't hurry their freeing; the colder the water the longer they adhere.

The Russian Method.—The above is the so-called "Russian Method," which made a great stir among fishculturists in America. We used to follow nature so closely that we took the eggs in a pan nearly full of water. In the New York *Citizen* of May 27, 1871, Mr. George Shephard Page had the experiments of M. Vrasski, a Russian scientist, translated, and it proved that impregnation was more perfect if the eggs and milt were put together before water was added, and when we tried it our per cent. of impregnation was more than doubled and the "dry method" at once became popular; yet sixteen years had intervened between the discovery of Vrasski and the translation. All American fishculturists had been wondering why a trout carried so many unfertile eggs, but had not stumbled on the secret. Of course one man claimed to have known it for years, but as it was his habit to claim every discovery, no one paid any attention to him, and if he really did know it and did not publish it he could not claim credit; yet that fact never hindered him. In

the reports of the American Fishculturists' Association, now the American Fisheries Society, it is on record that he bragged of showing Mr. Stone how to take trout eggs and filled the pan with water. I visited his ponds often and noted that he was picking out as many white eggs as any one.

The main points in taking eggs are: cleanliness of all implements; wet hands, to prevent removing slime from fish, which means death to them from fungus, a point that will be taken up under the head of "Diseases;" the rapidity with which the eggs and milt are brought together after extrusion, and the protection from changes of temperature. Temperature is a vital point. If the air and water are of nearly equal temperature, all right; but if the air is much colder than the water, set the pans in water at once. If in the pond, cover the pans, for the sun must never strike a trout egg. I shall probably say this several times, and will now repeat it: never let the sun shine on a trout egg. If you have a hatching house, take the pans there, and if the air in the house is too cold set the pans in a hatching trough.

Remember this: Water, whether in brooks or lakes, does not vary suddenly in temperature. It takes many days of warm or cold air to raise or lower a pond a degree or two; the change is slow; therefore the fishes, not being accustomed to sudden changes, cannot stand them. In winter the globe of goldfish stands in a room heated to 70° Fahrenheit. "The poor things need fresh water!" And they get it from the house service at near the freezing point, and after a few shocks of this kind that hardy and much-abused fish dies, and its owner wonders what killed it when "it had fresh water every day." A trout cannot endure anything like that

treatment, and if the adult cannot stand it, how can the little bit of life which is trying to assert itself in the egg which is only half an hour old stand it? Look to the temperatures of air and water when taking trout eggs.

The taking and impregnating of eggs is the most delicate and important part of fishculture. No man can become an expert by reading this or any other book. There are things that he must get by experience. I can tell him in words how to distinguish and strip a ripe trout, as far as words will go, but I realize that the directions are much like those books whose titles are, "The Violin Without a Master," and "The Art of Boxing," etc. After reading such works there is much to learn.

I believe that a novice may follow my instructions and, after noting his failures from year to year, he will get on the right track; but, if he can afford it, it will be years to his credit if he employs a competent fishculturist, and they are now to be had from the hatcheries of many States. I have taken eggs from the same trout many years without injury to her. A trout can retain its eggs if its stomach is empty, and they sometimes sulk as a cow does when being milked, but a full belly causes her to be glad to be rid of her burden.

SPAWN FROM WILD TROUT.

Brook trout usually run up into swift, shallow, gravelly streams to spawn, if there are such streams accessible to them. In Buck Pond, near Meacham Lake, Franklin County, New York, there is no inlet stream, and the trout spawn about the springs in the bottom.

I once helped the proprietor, Mr. A. R. Fuller, take eggs from fish which he netted there in about two feet of water. Yet I have known trout to spawn about spring-holes in a lake when there was a good inlet stream. In such cases it is difficult to net the fish unless the water is shallow and the springs near the shore, when a seine may be carefully put out around them and hauled; but great care must be used, for they will rush for deep water at the slightest alarm. In all cases there must be a pen or pool provided for such fish as are not fully ripe. Out of ten spawners only one may be fit for stripping on the day it is caught.

In parts of Canada, Vermont and the Adirondacks, the trout begin to go to the spawning grounds in August, and some will be ripe by the middle of September; in that case the spawning season is over in November. On Long Island the spawning begins about November 1, and continues into February in some years, the height of the season being in December. This is because the waters do not get cool early in the season, and all fall and winter spawning fish develop their eggs on a falling temperature; cold seems to stimulate the development of their eggs as warmth does that of the spring and summer spawners.

It is best to have everything in readiness a month before the spawning begins in order that those fish which run up at first may not be alarmed at weirs or traps placed in the water later. The males usually run up first, and often are a fortnight ahead of the females, and these males should not be caught or disturbed during their search for mates. Mr. J. W. Titcomb, Fish Commissioner of Vermont, recently read a paper before the American Fisheries Society on collecting the spawn of wild trout, and I cannot do better than to

quote the following, concerning traps, from his paper:

"*Location.*—The location of a trap should be made at a point where it is least likely to be inundated or washed out by freshets, which would allow the escape of many fish when they are most likely to be running in greatest numbers. A point on the stream near its mouth is advised, or at some place below any possible spawning bed, but not near enough to the outlet to be affected by back water from the pond. It is desirable to have a slight fall of water at the entrance to the trap. In order to avoid washouts, the selection of a point where the channel is broad is preferable. The slats of the weir occupying about four-fifths of the natural waterway will act as a barrier to raise the water above its natural level, more or less.

"*Construction.*—The trap is a V-shaped inclosure described by the mathematical term, 're-entering polygon,' made of slats varying in dimensions with the size of the stream and the force of the current. I used slats 1 inch square, planed on two sides, driven into the bed of the brook vertically, about ¼ inch apart, and nailed to horizontal timbers or hewn logs. This framework of horizontal timbers consists of one course laid at water level and a parallel course at the extreme height of the weir. The general idea of such a trap is the same as the pound net, there being an opening of 4 or 5 inches in the angle of the V. A gate can be arranged in the entrance with a lever reaching to some point obscured from the view of the entrapped fish, which can be lowered whenever the trap is approached for inspection. This method of trapping trout is not new, but requires more precautions than for the capture of other fish less active and gamy, and a few words

of caution to the inexperienced may be desirable. Build your trap to resist the greatest freshet the stream is liable to develop. The run of trout at such times will be greatest. Be careful to get a foundation that will not be undermined by the constant washing of the current between the slats. It is usually best to entirely surround the sides of a trap with slats rather than to depend upon the natural embankments. It is not necessary to use narrow slats for the sides of the trap, as no water passes through them, and the only object is to secure an inclosure from which fish can be easily dipped out. For a stream 6 feet wide I should build an inclosure about 6 feet square, the V extending into the inclosure about 3 feet.

"In many localities it will be found possible to dig side ditches above the trap and inclosures, at right angles with the stream, in order to convey surplus water away from the trap, and lessen the danger of washout or inundation. The bottom of such ditches should be considerably above low water mark to carry off surplus high water.

"A convenient place for the pens is just above the trap, so that the trout can be dipped from the latter into the former. They are constructed of the same material of which the trap is made, the upper side of the trap inclosure being used as the lower side or end of a series of pens. These should be made in shape and size to suit the location and number of fish expected to be captured, and the same precautions should be taken with them as with the trap to guard against washouts. In many instances the bed of the brook is hard gravel and stones of large size, preventing the driving of the slats into it. In such cases it is desirable to make an apron at the base of the slat-work, upon

which the water will fall as it passes through them, and prevent washing out of holes underneath the slats. This apron can be made of boards as an artificial bottom to the trap or pens, but a cheaper and quite as serviceable method is to place evergreen boughs or green underbrush at the base of the slat-work, covering the same with crushed stone or small stones from the bed of the brook, and then with coarse gravel. This feature of construction is very important. If there is a hole in the trap or pens large enough for trout to escape, they will surely do so. In fact, they will dig out under the slat-work if not properly guarded against. It is well to have planks extending over the trap and pens, on which one can conveniently stand to dip out the fish. Adjacent to the trap and pens, a rough board shanty can be constructed, or a tent can be temporarily used. There will be many stormy and cold days, however, and I advise having a shanty with facilities for heating it, and with a bunk where the attendant can sleep. Add to this equipment a reflecting lantern. Field stations of this description are usually some distance from habitation, and the ordinary comforts of camp life should be available to insure good work of the spawn taker."

NUMBER OF EGGS IN TROUT.

Mr. Titcomb gives a very interesting table of the yield of eggs from trout of different sizes, which is worth preserving. He says:

"Twenty-nine female trout, stripped of spawn at this field station November 26, 1896, were measured and weighed and the number of eggs yielded by each recorded. The girth, as given in the following table,

was taken before the trout were stripped and with a scale which might not be regarded as entirely accurate, but approximately so. Some of these trout had apparently dropped part of their eggs before being captured:

Length in inches.	*Girth in inches.*	*Weight* lbs.	ozs.	*No. of Eggs.*
13	7	1	0	1,394
18	7½	2	6	2,665
10	7½		6½	492
11½	6½		8	615
17	11	2	1	2,563
17½	11	1	14½	2,358
8½	4		3	130
12½	7¼		11½	1,312
12½	7		10	820
11½	6¼		8	410
11½	6		8	615
10½	5½		6½	308
12	7		9½	820
16½	9	1	10½	923
11	6		8	615
13	6¾		11½	1,025
17	10	2	1	2,665
13	6½		11½	923
11½	6¼		11½	820
12	6		10	718
16	9½	1	9	1,845
10	5¾		6¼	656
16	10	1	14½	1,948
16¾	10½	1	12	2,563
14½	8	1	2½	1,845
13¾	7¾		14	1,074
16	8¾	1	8	1,845
17	10¼	2		2,665
15	9¾	1	8	1,948
Total for 29 trout.....		31	6¾	38,580"

My estimate given below is not as large as this, but Mr. Titcomb gives figures from a record, while mine, written before I saw his, is merely an estimate such as would be given offhand in reply to a question.

The flow of water in a hatching trough should be about 100 gallons per hour for each 10,000 eggs.

If the work is distant from a hatchery there should be troughs or trays for developing the eggs as they are taken. These will be treated in another chapter. In gathering eggs in streams on Long Island my men

had less than a mile to go from the hatchery and brought the eggs back with them each morning.

The following is my estimate of the yield of eggs of trout of different sizes:

Age.	*Weight.*	*Eggs.*
1¾ years.	3 to 5 oz.	50 to 160
2¾ years.	14 oz. to 1¼ lbs.	700 to 1,000
3¾ years.	2 to 3 lbs.	1,200 to 2,000
Not known	3½ to 5 lbs.	2,000 to 4,000

These were pond-fed trout and the ages were recorded from March 1 of each year. Thus: A trout of March 1, 1890, would be 1 year and 8 months old in November, 1891; by some the fish would be classed as two-year-olds and by others yearlings. With me they were "yearlings" until actually two years old. I have had much larger trout at the ages given above, but have given a fair average weight.

PACKING EGGS FOR SHIPMENT.

No eggs should be packed for shipment until the eyes are plainly visible, and, in fact, the older the better, if possible. The embryo before the eye stage is reached is very delicate and easily killed by a jar of any kind; even a shaking of the hatching trough may injure, if not kill it. But after the eyes can be seen the embryo begins to get strong and will bear rougher treatment.

For transporting freshly taken eggs from the streams to the hatchery my men used tin water pails and brought them in water, if they came down the mill-ponds in a boat, but if they came from a stream down

the harbor and walked home they had a box 1 foot each way with a swinging door. In this there were light frames ½ inch deep with bottoms of canton flannel, woolly side up; on these the eggs were floated, under water, and evenly distributed in a single layer until each box was filled. An ordinary trunk or drawer handle on the top served to carry it by. On arriving at the hatchery the trays are put in the troughs, and by the movement of water by a feather the eggs are gathered to the lower side of the tray and then turned out. It does not hurt them to fall when in water, but to fall in air and strike the surface of water is fatal.

To pack for a week's journey by rail the eggs should be well advanced and the embryo quite well colored—say, forty-five days old. If only a thousand are to be sent, a box of tin or wood 8x4x3 inches deep will do, but not a cigar-box, because of the odor. Make holes in the bottom for drainage, lay an inch of living swamp-moss—sphagnum—on the bottom, then cover with mosquito netting, one layer of eggs covered with netting, a thin layer of moss, and so on, covering with moss. Press the cover down hard; you can't hurt them by pressure of moss; and they should be put up so firmly that if dropped endwise on the floor not an egg would stir. Then get a larger box and pack the smaller one in it with at least three inches of sawdust on top, sides and bottom, and mark: "Fish eggs; keep cool, but don't let 'em freeze."

The principle is this: The little fish within the egg needs oxygen as well as an adult. It would die in still water after the oxygen was absorbed, just as its parents would. The living moss gives off oxygen and holds the necessary moisture, and that's all there is of it. The mosquito netting is a convenience to the one who un-

packs them because he does not have to pick the eggs out of the moss.

To pack eggs for foreign shipment is a different affair, although many fishculturists do not think so, and pack for a two-weeks' trip as described above and let them go.

The late Prof. Spencer F. Baird, Fish Commissioner of the United States from 1871 until his death in 1887, appointed me in charge of foreign exchanges of eggs and fish in 1877. In his day there were constant exchanges with Germany, and shipments of eggs of trout, quinnat salmon and our lake whitefish to England, France and Holland. I opened all foreign boxes, picked out the dead eggs, gave the living a "drink" and a wash, repacked what were good and sent them to the different Government or State hatcheries. I repacked all eggs that were to go abroad, and in 1877 and 1878 went with the shipments to Germany. These things are mentioned to show my right to an opinion on the subject.

In the years named I repacked the eggs of quinnat salmon on flannel trays, above which was a box for ice, which by its drip kept the eggs cool and moist, and the trays were so arranged as to be inspected and the dead removed, for in dead eggs lies great danger to the living. On the first trip only 25,000 were so packed, while the remainder went in the original packages, without opening, as per order from Prof. Baird by request of the original packer. My box turned out well; the others were a total loss, and after that I was given *carte blanche* to repack as I saw fit. The next year I took 100,000 over safely and received the thanks of the Deutsche Fischerei Verein, a silver medal from the Societe d'Acclimation, Paris, and $200 from the

King of Holland, sent through Mr. C. J. Bottemanne, Inspector of Fisheries, Bergen op Zoom.

In after years I packed as follows: A layer of eggs on trays, a cover of mosquito netting and a thick layer of moss; then a tray with perforated zinc bottom

The First Refrigerating Box for Shipping Salmon Eggs to Europe.

filled with ice, cover screwed on and the box packed in another with sawdust. This packing did not need an attendant, and at the World's Fischerei Austellung, Berlin, 1880, it received a bronze medal.

Mr. W. Oldham Chambers, secretary of the National Fishculture Association of England, in his history of fishculture, "Land and Water," March 27, 1886, says: "We may well take a lesson from the American system of packing, which is very simple, but most efficacious in attaining the desired end, which is to diminish as much as possible the rate of mortality through injury. In the first place, the ova are placed into trays, consisting of calico (canton flannel) stretched upon wooden frames, which are deposited one above the other in the centre of a large box, each tray being interlaid with moss. Around the pyramid of trays, which are fixed firmly into position, a partition is reserved, serving as a receptacle for ice and sawdust—two most important factors in transmitting ova. On arrival at their destination the eggs can be readily unpacked by removing the trays from the box, clearing away the moss between each, and turning the ova *en masse* by means of water into the hatching troughs. The originator of this capital method is, I believe, Mr. Fred Mather, of New York. I am able to testify to the fact that not more than thirty eggs out of every thousand sent me at various periods have perished during the journey from New York to London, which is an evidence of the skill displayed in packing them."

Very often I received foreign eggs packed in the old style, and after picking out the dead ones reported the remainder in good order, being required to make an immediate report. But I learned to deduct at least half because, with my first report in hand, I was expected to turn out a proportionate lot of fry.

Many "good" eggs either died a week later or produced deformities which could never live. It is a fact that an injury to an embryo is not always fatal (a no-

table instance of this may be found in the first chapter of Tristram Shandy), and fish eggs may be injured in transit by heat, concussion, or a lack of moisture so that the embryo will come into the world only to die.

Concussion is more immediately fatal than a high temperature; it kills within a few days. Lack of moisture is shown at once by indented eggs, and upon the degree of indentation rests the damage. I have experimented with such eggs and have found that those only slightly indented have produced good fish, while others somewhat drier did not. A high temperature on eggs of *Salmonidæ*, and it is of these that I speak, makes weak embryos, if they live to break the shell. They hatch head first, and all fishculturists know that such fish have a small chance for life, or they have not strength enough to straighten from the coil in which they have been and are "whirligigs," spinning round in one direction at every effort to move. These die of starvation because they cannot swim.

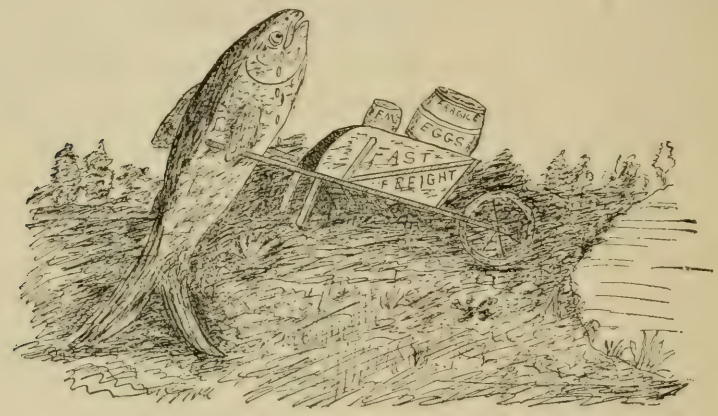
A lot of saibling eggs received from Germany looked first-rate, but one-fifth of the embryos had not strength enough to straighten after hatching. Another result of high temperature *en route* is a softening of the egg, either the outer covering or some part beneath, and these embroys hatch but do not live to take food.

Of some eggs of our lake whitefish sent to me by Mr. Clark for transmission to Germany, and repacked in my boxes, the late Herr von Behr wrote as follows:

"Berlin, Feb. 1, 1881.

"MR. MATHER: It is wonderful how good the whitefish eggs arrived. I divided them and sent them to many parts of Germany and Austria, with no loss to speak of. This manner of packing may be immor-

tal! And if the promised trout eggs come in equally good shape I will be happy."



CHAPTER IV.

CARE OF TROUT EGGS.

These things will kill your eggs in the troughs or in the nests, or redds, in the stream: The sun is deadly; two minutes of direct sunshine through a crack will kill every egg it strikes. Sediment will close the pores in the egg and smother the embryo. A sudden jar on the trough, a heavy weight falling on the floor or concussion of any kind will either kill or deform the embryos, according to their stage of development. Rats and mice will eat the eggs, and one dead egg will kill all that it touches if left until fungus forms on it—say

in three or four days. In the streams all these dangers are mutiplied ten-fold, and to them are added: ducks, geese, swans, eels, suckers, chubs, bullheads and yearling trout, for the eggs of trout and salmon seem to have an attractive odor for fishes, and in England poachers use salmon eggs, probably not impregnated, but direct from the fish, as a lure for trout that is said to be irresistible, and salmon roe is even salted down for that purpose.

Hatching the eggs of brook trout is a simple matter if proper arrangements are made at first. The conditions required are a steady flow of water at a low temperature, the absence of sediment, and the exclusion of light, enemies, and all decaying animal or vegetable matter from the water, especially such as might arise from dead eggs—conditions which can usually be best obtained where a spring rises, but are often available below it if sufficient fall can be obtained.

Let us suppose that the owner wishes to make an experiment to see what he can do in hatching trout, with which he has had no previous experience, and does not care to go to the expense of building a hatching house until he has proved his ability to manage one. He wishes to try 10,000 eggs with as little expense as possible beyond their cost.

A tight trough of clean, well-seasoned pine, ten feet long, fourteen inches wide, and eight inches deep, with one end open, will do. Make according to directions for troughs. Place strips across it at eighteen inches apart, making nests an inch deep; cover this with fine, well-washed gravel, about the size of buckwheat, or larger, to the depth of half an inch, put on a cover with hinges and lock, place a screen in the lower end to keep out mice and insects, and the trough is then ready. The

trough may be placed by making a dam with a board, a foot or more in height, and, tapping it with a half-inch pipe, let it run into the upper end of the trough, which should be slightly raised, so that there will be a small ripple over the strips, but not current enough to carry away the eggs when placed upon the gravel.

If this trough is in a spring house, or a hatching house is built, where a settling reservoir can be used, it will be found a great help in keeping the eggs free from sediment which will collect and, partly covering the egg, interfere with its vitality by depriving it of its power of absorbing oxygen from the water in a manner analogous to breathing. The trough being in readiness and the eggs received, fill the trough by a dam at lower end and place the boxes in the trough before opening until they have acquired its temperature, then take a pan of water, remove the eggs and rinse them free from any dirt in the moss, pick out the few dead ones, which you will at once recognize by their milky whiteness, dip the edge of the pan under water and let the eggs drop on the gravel to be afterward distributed with the wing feather of a fowl. Ever remember these vital rules: never let the sun shine upon the eggs, never pour them through the air to strike the surface of the water (although they may fall any distance under water) and never expose them to sudden changes of temperature.

Having placed the eggs on the gravel, all that is now required is a daily inspection to see that the water is running steadily, and to remove such eggs as may die from time to time, to prevent them from decay and growing a woolly fungus which is very deadly. They should also be feathered over as often as any sign of a deposit of sediment is observed, beginning at the head

of the trough and working it down. This requires to be attended to much oftener when some distance below the spring, as all disturbance above tends to foul the water and the flow in the trough is not strong enough to carry it through. A box with the bottom knocked out, and a fine sieve substituted, is good to fasten above the pipe to keep leaves and coarse particles out.

In the hatching house the use of gravel is nearly obsolete, although Mr. Frank N. Clark, a veteran fish-culturist of acknowledged ability, has recently returned to its partial use, as has been told in these pages. Frames, with wire bottoms, are used, as described under that head. The frames are often placed one above the other to the number of five or six, thereby increasing the hatching capacity of the trough as many times, and rendering the cleaning easily and thoroughly done by raising the frames, sprinkling them with a common watering pot, and washing out the trough with a small broom; with this system no strips are used, but for simple experiment the gravel will do, it being the old system under which we worked for years before the introduction of the frames. But while five or six layers of eggs may be developed, these should not be allowed to hatch in the trough or the young would be smothered.

A trout egg requires 60 to 100 or more days to hatch, according to temperature, and the colder it is, down to freezing, the longer it takes. Warm water, 60° Fahr. and upward, hatches them quickly, but leaves the embryos weak and liable to die. After hatching, the water in the trough may be deepened and the current slightly increased; the strongest of the fry will work up stream and the weaker will try to hide or be carried against the screen, where they will finally be suffocated by the

pressure of the water closing their gills against the wire. These had better be turned loose before dying.

TOOLS OF THE CRAFT.

The implements in use in the troughs are few and simple. Wisp-brooms to clean troughs and trays from slime. Strong feathers in wooden handles to move eggs that may be washed in heaps—the wing feathers of geese are best, because the quills are stiffer. Nippers for removing dead eggs or other substances are best made of red cedar; a piece 7 inches long by $1\frac{1}{4}$ inches wide and $\frac{1}{2}$ inch thick will do. Bore a $\frac{1}{2}$-inch hole an inch and a half from one end and rip from the other end into the hole with a saw and then trim down until you have a pair of nippers that are springy and will open themselves. Either flatten and hollow the ends to hold an egg, or better still, whip on loops of fine brass wire. Then make square frames of heavier brass wire and put in a wooden handle, the frames being 3 inches square. Cover them with "millinet," such as milliners use, sew it on perfectly flat and it is handy for picking up lots of eggs that have got off the trays or for other purposes. Strong glass tubes, about three-quarters of an inch outside diameter, and ten inches long, are very handy for picking up eggs or embryos for examination. Stop one end with the finger and put the other end near the object to be lifted. Remove the finger quickly and let the water rush in with the eggs, dirt or whatever you may wish. Close the top again and also the bottom and then you can examine the object at leisure.

These things, with a microscope and thermometer, are all that I need to hatch several millions of trout. Go

over the eggs each day, remove all dirt, dead eggs or other matter; keep everything clean, see that the flow of water is regular and wait for the hatching to begin.

HATCHING IN BULK.

Some years ago I devised a series of trays to hatch in layers, which improved on the Clark-Williamson trough, which had fixed partitions in it where the water went under one and over the next. (See cut.) Fig. 1 is copied from plate XVI, Report U. S. F. C., 1872-73,

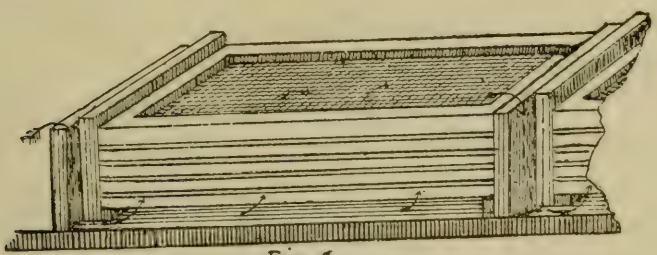


Fig 1

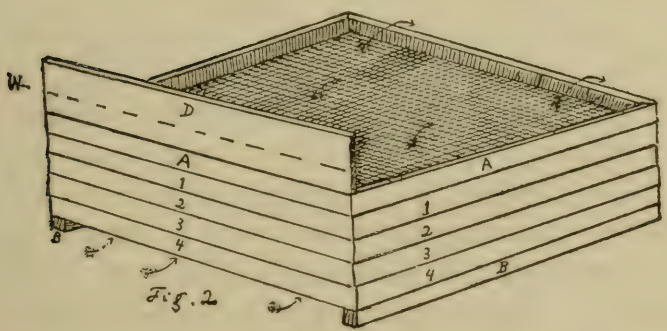


Fig. 2

and shows a "nest of trays in Williamson's Double Riffle Hatching Box." It will be noticed that the dams are permanent and in pairs, the upper one being the lowest to permit the water to flow over it and up

under the next one, which extends above the water line, thus forcing the water downward to flow up through the nest of trays and then down again.

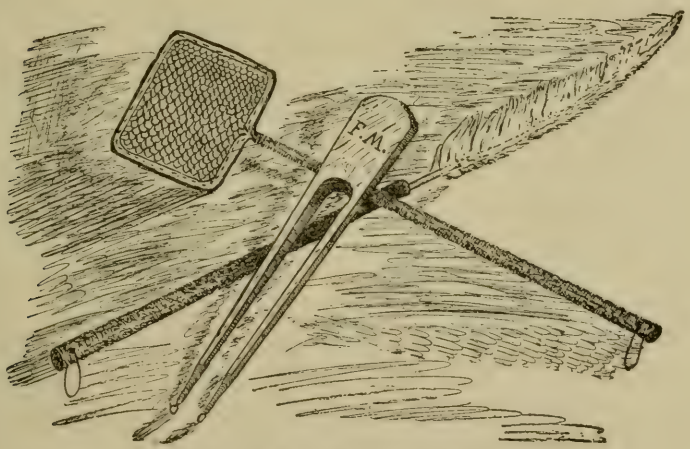
Fig. 2 is my system, so arranged as to secure the same result and yet have no dams in the troughs, which may be used to hatch single layers when the house is not crowded. The trays should be square and of exact size, only one-quarter inch smaller than the inside of the trough. I have urged that all troughs be of exact size inside, in order to avoid ill-fitting trays. Each tray should fit any trough. Rabbet the bottoms of the trays so that the wire-cloth is sunk in, for the trays must set tightly on each other. Use No. 14 wire-cloth, which is small and does not injure the embryos by letting sacs and tails through.

The top tray, A, has no eggs on it, but has a stop-water, D, fast to the side, which must be put up stream. The lower tray, 4, has a half-inch square strip on three sides, which forces the water up through the eggs. The water line is at W. To each gang of trays, four or more, there must be the two special top and bottom ones. The sets of trays are kept from floating up, or from escape of water on the bottom, by braces across the trough or by weights. In cleaning the eggs the trays are floated up and one tray after another is gone over. They should be picked over twice a week until hatching begins, and then only once to remove shells and pick out dead. The fry can be kept in these frames until ready to take food, when they may be put in floating boxes in the ponds to be fed or may be turned out.

The capacity of a set of four trays, as described, is 2,500 salmon or 7,000 trout, thus increasing the hatching capacity of a trough fourfold and holding the fry safely until the smothering period has passed. The

embryo fish lie quietly on these frames because there is but little light, a thing they avoid, but if the "rabbet" for the wire-cloth is deeper than one-sixteenth of an inch, letting the wire in deeper, there will always be some fry on top of the frame below to bother by escaping when cleaning. A trough full of these trays does not show up much "business" to a visitor, but it is of use when the hatchery is crowded.

UNIMPREGNATED EGGS never change from the time they are taken until they turn white, which they may do at any time, often not until hatching begins. With a microscope I can see the change in a trout egg at three days old and with the eye at ten to twenty days, accord-



SMALLER TOOLS OF THE CRAFT.

ing to temperature. At first all the eggs have a ring at the top; no matter if it is rolled over the ring will come up. The first sign of impregnation under the microscope is a division of the yolk into halves and then quarters; then comes the "mulberry mass," and afterward the line of the backbone and the eyes. But the egg with no fish in it, if it has not turned white, holds

its ring, and when the eyes appear the "ringers," as we call them, can be picked out and fed to the yearlings; and they are very fond of them. If eggs are packed for shipment all ringers should be picked out, as they "die" at the slightest disturbance, and only fertile eggs should be sent.

CHAPTER V.

CARE OF FRY.

The Century Dictionary defines "fry" as "the very young of a fish." In that sense I use it. Technically the young fish is an embryo while in the egg and after bursting the shell until the umbilicus is absorbed. But I have declined to use the French word "alevin" for the hatched embryo, just as I decline to use the Latin "ova" for eggs. English fishculturists advertise "eyed ova." There's a mouthful! What's the matter with a good English word like eggs? I would as soon think of asking a waiter to bring me "two fried ova" as of calling fish eggs by a Latin name to show my learning. Most of American fishculturists speak of "eggs of fish" and call embryo trout "fry" until the sac is absorbed, when they are "babies" until they are entitled to be termed "yearlings."

A troutlet which bursts the shell head first or lets any part of its umbilical sac out in advance is a poor, weak critter whose shell has worn thin and it had no power to burst it. Few such live. A strong, healthy embryo trout rips the shell open with its tail and wiggles about

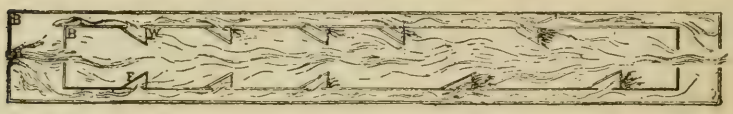
with head and sac in the shell, driving it here and there as if it meant business until the shell drops away.

In trout culture the hatching is a simple matter, and one that is easily learned, so that a child can attend to it; the real difficulty for a novice being in keeping the young fish the first year and overcoming, first, the disposition of half of them to die without apparent cause or provocation during the first three months, and, secondly, the propensity to escape through an unseen crack or a defective screen; but the second season all that are left seem to thrive well and to be contented with their confinement, provided a gate is not left open for them to get into the stream, and even then they are liable to return at the spawning time.

A newly hatched trout would never be classed as a young trout by one who sees it for the first time. They look like small threads of albumen, which have great eyes, and attached to the belly is the great yolk-sac, about as large as the original egg. They cannot swim, but move about on the bottom in an apparently aimless manner, seeking to avoid light. In the brooks they would scatter and bury themselves in the gravel, but in the troughs they huddle and crowd in corners to avoid the light, for they take no food until their haversack, with thirty to forty days' rations, is exhausted and their instinct is to hide. This is a critical time. They may pile on top of their fellows and smother the bottom ones. This must be prevented. Keep the upper parts of the trough darkened with covers or window shades and let the outlet screens be in the light. This will prevent them from squeezing in any crack about the screen and dying there, or of their letting tails or parts of sacs through the wire-cloth and perishing.

The crowding is worse while they are young and deli-

cate, say for the first fortnight, and I have put stones and bricks in the troughs to induce them to scatter. But these are not good; some will wedge their heads under them and die. If kept dark by covers, as aforesaid, for a couple of weeks they will come out right, for the crowding is merely to escape light, and when the covers are lifted the little fellows which were quiescent begin to scatter to find a dark place. Under this management the strong fellows will be well up in the trough and the weaklings and deformities will be sifted out by the incessant working of their tails to keep their places and will be found about the foot of the trough; crooked



To Prevent Fry from Crowding.—This is a small inner frame to place in the trough. BB, outer and inner troughs; F, an inner projection of wood or tin; W, wire cloth through which water from the outside flows. By W. P. Seal in *Forest and Stream,* Feb. 19, 1891. The fry are supposed to gather below the wire cloth W.

tails, double-headers and all others not fitted to survive will be found near the outlet.

The newly hatched trout is much more delicate than the egg and must be treated accordingly. Move them, when necessary, by pouring water on them or by making currents with a feather, but don't touch them. If you wish to disturb them to remove the dead or to send them toward the head of the trough take a piece of half-inch pine board, a little less than the width of the trough and one inch less than its depth; tack a strip on its upper edge to rest on the top of the trough and slide this down the trough with some force. The water will rush

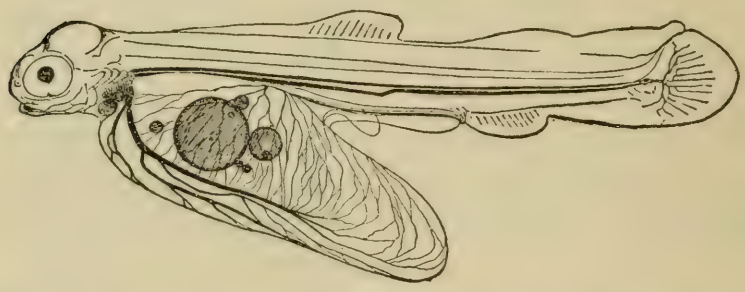
up stream and carry the fry with it, and a few such movements will send them swirling toward the head of the trough. Delicate as they are to the rough touch of a feather, the swirl of water does not hurt them; it merely carries them with it and they come in contact with nothing but water.

A trout or salmon, newly hatched, is a beautiful thing under the microscope. The circulation of blood is shown more clearly than in the frog's foot, which is the standard thing to use in school work; but the frog is available at all times. Under the microscope the caudal heart can be seen up to the fifth day, when it is absorbed. The streams of blood in the sac seem to flow like creeks, now dammed by a lot of corpuscles and then breaking away and flowing on, while the plexus in the tail shows the capillaries returning the arterial blood to the veins and back to the gills for oxygenation.

The loss in eggs is largely due to the lack of impregnation, although some few embryos die after the eye-spots show. The loss after hatching and before feeding is largely from malformations and weaklings if there has been no smothering, a thing which the expert fishculturist does not allow to happen, because his trained eye detects the first sign of crowding and stops it. But as all this is not written for the expert, but for the beginner, all these dangers are mentioned. If the beginner buys 20,000 eggs from a reliable dealer he is sure that each egg has a fish in it when the lot is put up. If he expects that he will hatch and rear 20,000 trout he will be mistaken. Why should he expect it? He can't raise 900 chickens out of a thousand that are hatched, not to mention those which died in the egg. He can't average nine out of ten colts, calves or children if he is doing business on a large scale, and why should he ex-

pect fish to be an exception? Given 20,000 good trout eggs, with the eyes to be seen in each egg, they are about fifty days old and are due to hatch in ten or twenty days more. He will pick out 500 white eggs before they begin to hatch and 500 more in dead and deformed embryos that never could live. That is only 5 per cent. loss before feeding, and is very low. It is more likely to be twice that number, yet there is no fault to be found with the seller nor with the receiver. It is the natural mortality which is common to all young animals. It is part of nature's scheme in animal increase, and no man can improve it.

We not only impregnate more eggs than is possible in



EMBRYO SALMON, showing yoke sac with oil globules and veins, also the embryonic fin with indications of permanent fins.

a state of nature, but we protect both eggs and embryos until the little fellows are ready to take food, a period of some seventy days in the egg and of at least thirty more before the sac is absorbed. This nearly covers the winter months and brings our protégés up to the time when insect life, either in perfect form or larvæ, is stirring in the spring and affording food for the baby trout which, having absorbed its yolk-sac, is swimming clear of the bottom, heading up-stream and examining every tiny bit that floats down. It takes a morsel in its mouth,

throws it out and settles down on the bottom to rest, its curiosity having been satisfied.

Take up one now in a glass tube and note that the embryonic fin which ran from the insertion of the dorsal fin around the tail to the anal fin, like the fin of an eel, has been absorbed and the permanent fins are developed. The sac which seemed to be absorbed appears like a bit of amber in the cleft abdomen, as though the fish were about to split open. The sac is almost absorbed and the walls of the abdomen will join together over it and the embryo will be a trout in a few days. Yet it will take food by the mouth before the sac is fully absorbed, and a proof of this is not in its seizing floating particles, but in its passing of ordure. Nothing passes the embryo trout while subsisting on its sac; the yolk is pure nutriment, with no waste, but when it begins to feed with its mouth there is a waste which is common to all animals after leaving the embryo stage, and the troughs must be feathered down every day.

The fish with curled tails cannot be helped. They cannot swim and must spin around in one direction, and, being unable to seek food, must die. The "double headers" occur in many shapes, from two and even three heads to fish merely joined at the tail, and even "twins," which were two apparently perfect and distinct fish, but with only one umbilical sac between them. I have tried to rear thousands of these monstrosities and have had them take food with both heads for several days and then find them dead some morning. The salmon and trout seem to be more given to producing monstrosities than any other fishes on my visiting list.

A little salt is good to sprinkle at the head of the trough occasionally if there is a sign of fungus from fin or tail nibbling.

CHAPTER VI.

FEEDING FRY.

The time of absorbing the sac we roughly state at about thirty days, but it varies according to temperature. Those hatching about February 1st, in cold water, are longer in absorbing it than those coming out a month later, especially if warm rains come on. From twenty-five to forty days would be more accurate.

When nearly ready to take food they head up-stream, and the strongest will be at the inflow. They will crowd in a corner if there is an eddy there, and some may try to jump up the incoming stream and land on the floor. To remedy this make a little box, about 6x9 inches and 5 deep, with a bottom of fine wire-cloth or perforated tin, and hang it so that the water pours into it, the bottom being a couple of inches below the surface. Such a box is good to put in when hatching begins, as it catches all insects and crustaceans which might injure the fry. Now it will distribute the inflow through small holes and prevent jumping out.

When they begin to rise and examine small floating objects care must be taken that the trough is not overcrowded, for if they are crowded they will soon nibble fins and tails, even though food is plenty. They seem to do this from irritability at being crowded and nip at a tail as if to say: "Get out of my way." When a tail or pectoral fin has been nibbled it turns white, is mistaken for food and is picked at until fungus sets in and the troutlet dies. In a trough 10 feet by 14 inches, with

water 6 inches deep, 7,000 trout fry are quite enough to feed. If the trough is 14 feet long 10,000 may be retained. The remainder, if any, should be placed in other troughs or in floating boxes in the ponds. For description of these boxes see the chapter on shad.

To feed the fish which we should have from 10,000 eggs take a piece of beef liver as large as a hickory nut and scrape it with a sharp knife until only fibre is left; take the scrapings and pass all of it that will go through a screen of about twenty wires to the inch by rubbing and pressing it with a flat piece of shingle and scraping it off the under side. Place this on a board and add a few drops of water to make a thin paste, and then drop in a little at a time, taking care not to feed more than they will eat, in order not to foul the trough. It may be flicked from a knife blade down the trough. My favorite is a "knife" made of hard wood, something like a paper cutter. Watch them and see if they take it. Feed carefully all down the trough. The motion of their tails will now send most of the waste to the foot of the trough, yet it should be feathered as before.

In a few days their appetites will increase greatly, and it is better to feed little and often than to try to give a big feed twice a day. I would not recommend any person to undertake to raise young trout by artificial feeding in troughs or boxes for the first three months unless they can feed them every hour. The appetite of the juvenile trout is as frequently intermittent as that of other young animals, and requires one to stand over them almost constantly.

When I began trout culture (1868) the only book on the subject was "American Fishculture," by Norris, published in that year and now out of print. It contained all that was then known, which was but little.

Norris speaks of different kinds of food for fry, such as "Liver or lean meat, boiled hard and grated; the yolks of eggs, boiled hard and reduced almost to a powder; raw liver, chopped fine with a long sharp knife; fresh or coagulated blood; fresh shad or herring roe, raw or boiled; thick milk or bonnyclabber and curds."

I had an experience in trying most of these things. Mr. Stephen H. Ainsworth, the first man to breed trout in the State of New York, cautioned me not to overfeed the fry. I had taken some 50,000 eggs from wild trout in my first year's work and had bought 20,000 more, and my few troughs were full. My loss in unimpregnated eggs was great, for I had no instructor. I had about 35,000 fry. I must try different foods and observe their effect, being careful not to feed too much.

The boiled egg was a failure. It dissolved and spread over the gravel and grew fungus; the fry were all head and no body, looking snaky. The curd acted the same way; clotted blood was worse. All these troughs must be cleaned if the fish were to be saved, and a vile mess that gravel was. The grated boiled beef was not so foul, but the fish were evidently starving. Although a novice, I could see that. Those fed on fresh liver were doing well comparatively, but were slim and "all head." I changed to liver in all the troughs and some fish began to pick up, but thousands died. I caught a few "wild" ones that had either escaped from my troughs or been naturally spawned, and their deep bodies, broad backs and relatively small heads showed that my fish were not well fed and were just kept alive. "Why," I asked myself, "should a young trout be restricted in its food? Surely it gets all it wants when wild." Then I fed them all they would eat every half hour, and could see them pick up, but

they never made thrifty fish. I saved some 11,000 to live through May, but I knew more about feeding trout than when I began.

Along the Massachusetts coast the trout breeders feed the eggs of haddock to the fry and get good results. Shad eggs, named by Norris, come too late to be of use. I've mixed cream with liver to keep it floating longer, but don't care for it. Bellies of soft clams, *Mya arenaria,* the "maninose," have been used by me with good results, but beef liver is the best food for trout and salmon fry in the troughs that I know of. Make it fine at first, coarser as they grow, and crowd it to them.

During late years I have used the sausage chopper of the Enterprise Manufacturing Company, of Philadelphia, with good results in labor saving; but two new plates were made with holes one-eighth and one-sixteenth of an inch, as the smallest holes in the plates that come with the chopper are one-quarter of an inch. The plate with smallest holes was used until the babies could take larger particles. Yet after passing this chopper the food must be sifted, as described, because no fibre must be fed, as it passes undigested and is seen as a long white string hanging from the fish, and is troublesome to pass. It may cause inflammation and death. The Enterprise chopper is a great improvement on the one in use years ago and figured by Mr. Stone as "Starret's American chopping machine," which had a vertical knife worked by a "walking-beam" in a revolving cylinder, because the meat must pass through holes of a certain size. It is the best chopper on the market.

Milk and cream have been used as food for the fry, but they are not complete and wholesome, and under my feeding produced great mortality. Shreds of beef, brains and the spleen, or "milt," as butchers call it, are

all good foods if cut or scraped and passed through the sieve, which should be changed to a larger mesh as the fish grow; the soft part of clams and eggs of other fish make excellent food for the very young trout, but the eggs of hens will make filthy troughs on account of so much of the yolk becoming dissolved and settling to the bottom, and there decaying.

On Long Island I found the bellies of soft clams quite good, but returned to beef liver. As the suckers spawn in early spring, their eggs should be good food for baby trout, as I know that the flesh of suckers is for adults.

The food of the very young wild trout consists of the newly hatched larvæ of water-breeding insects and the young of the smaller fresh water crustacea, food that we have no way of supplying in quantity, and my own experiments, with half a dozen barrels of rainwater, to breed "wigglers" (the larvæ of mosquitoes) were successful as far as producing good food for the fry went; but as it took them about five or six days to grow, only one barrel could be strained each day, and the production was only equal to the demands of a few hundred fry, so that to carry it out on a scale sufficient to feed 50,000 would have made an imposing array of barrels and involved great labor and expense. The beauty of this kind of food is that it keeps until used, as well as being most suitable and wholesome.

Mr. Charles Hoxsie devised an automatic feeder for trout fry, intended to dispense with hand labor. An underflow wheel of 10 or 12 inches diameter was put in the distributing trough and a crank of 1 inch moved a $\frac{3}{8}$ strip which was suspended by cords over the heads of the troughs and gave it a 2-inch reciprocal movement parallel to the distributing trough—a wire would

do as well and would not buckle as my rod did if there was any obstruction. A tumbler rested on a strip at the head of each trough, and in the bottom of it was bored a ¼-inch hole; in this hole worked in and out a bit of wood, about half the diameter of the hole, attached to the rod by an arm. The tumblers were filled with food wet to the proper consistency; the wheel revolved; the long rod worked back and forth, forcing the wooden pins in and out of the tumblers and dropping the food automatically. I put one in the hatchery at Cold Spring Harbor, N. Y., but found that it required constant attention to see that the tumblers were not clogged and that their contents were fluid enough but not too fluid. In theory the thing was perfect. In practice the water settled to the bottom and went out first, and when it was gone the liver would not flow; it remained in a solid mass and formed an arch above the wooden pin, which tried to do its duty but could not.

Such experiments are of value, even if the results are failures, for they show us what to avoid. Mr. Hoxsie looked after his own trout and had comparatively few. I had more, and, working for the State, it was desirable to produce the best results without too great regard for expense, and so I went back to hand-feeding with brains behind it. I had a man, Foster Van Ausdall, who was the most persistent trout-feeder I ever knew, and—I am glad to say so out loud—he loved to see trout feed, either old or young, and he was on his feet all day feeding. When he came to the lower end of the last trough he would begin at the head of the first again, and so he went the rounds day by day while the other men were on the road with trout for stocking public waters. He loved his work, and the trout showed it.

HOW OTHERS FEED FRY.

The late Sir James Maitland, Bart., had a large breeding establishment at Howietoun, near Sterling, Scotland, and made it a commercial success. In a pamphlet "On Stocking Rivers, Streams, Lakes and Reservoirs with Salmonidæ," published by his secretary, Mr. J. R. Guy, Sterling, N. B., 1892, Mr. Maitland tells how to feed fry. While I do not agree with his views, they are quoted because he had an extensive experience, and therefore would consider that his ideas are as good as mine, if not better. He says:

"The best and most economical food for trout fry costs about 1s. 4d. per pound (nearly 32 cents)—that is to say, one pound of this paste goes further, and produces much better results, than sixteen pounds of liver, because it is more nourishing and there is no waste. The food is prepared by weighing several pounds of fillet of beef—not beefsteak, which is too stringy, nor a piece off the sirloin, which is generally too fat. Fillet of horse is equally suitable with fillet of beef, and sirloin of horse, being generally very lean, is nearly as good. . . . Mutton is not suitable. All the fat being carefully scraped off, and the meat weighed, it is pounded in a large marble mortar and passed through a coarse sieve. The yolks of hard-boiled eggs are then added, nine eggs being allowed to each pound of meat. The eggs should be several days old, as, if new-laid, it is impossible to boil the yolk until it is mealy. . . . When the yolks of eggs and meat have been thoroughly mixed in the mortar they are passed through a fine wire sieve and kneaded into a stiff paste. This is rolled into the shape of a thick sausage and cut and rolled into

large pills, each sufficient to give one meal to five boxes. . . . When the food is all prepared it is taken to the hatching-house and one pill placed on the edge of the fifth box in each row. One of the girls then goes round with a feeding spoon, and, beginning at the bottom box, presses the food through the perforated zinc of the feeding spoon, which reduces it into fine vermicelli. When the threads are about two inches long they are shaken off into the water. . . ."

In 1891 I sent circulars to several trout breeders asking a few questions. They were: "3. On what do you feed the fry for the first three months, and how?" "4. What do you consider to be a fair percentage of fry brought through the first six months, reckoning from the time of their first taking food?" "5. Do you feed fry in hatching troughs? If so, how long?" Here are some answers:

Charles G. Atkins, Superintendent of Salmon Hatching Station, U. S. F. C., East Orland, Me.—"3. In troughs on chopped liver for one month or six weeks, then part on same food and part on maggots; majority on maggots this year. From July 15 to 30, 1891, have fed about 200,000 on maggots. 4. Sixty per cent.; but we have done much better. In 1889, out of 109,965 Atlantic salmon eggs, counted in winter and early spring, we saved until the next October 91,856, or 83 per cent., actual count at start and finish; that is my very best. 5. All summer and fall, sometimes through the winter."

E. M. Robinson, Superintendent U. S. F. C., Mammoth Springs, Ark.—"3. Beef liver, but don't approve it. 4. Seventy-five per cent. 5. No; we use ditches 5 feet wide, 15 to 20 feet long, and shaded half way the length."

E. F. Boehm, Superintendent N. Y. F. C., Sacandaga Station.—"3. Do not feed fry here; can't get food. 4. Seventy-five per cent."

C. S. White, Romney, W. Va., Fish Commissioner.—"3. Milk in forms of clabber and curd, eggs, liver, lights, corn-bread and fish roe, fed upon sods, which are removed every three or four days. 4. Fifty per cent., averaging year by year. 5. About three weeks."

[I am not sure but Mr. White mistook the questions to mean adult trout.—F. M.]

Dr. R. O. Sweeny, Superintendent U. S. F. C., Duluth, Minn.—"3. Finely grated fresh, sweet livers, mixed with thick, sour curd of milk, of the consistency of paste, of such gravity and consistence as will drop from a spoon and sink to bottom of trough in a lump. 4. I think I can honestly say that the shrinkage is not over 10 per cent. 5. Have held them till August in the troughs, but they must not be crowded or there will be cannibalism."

George T. Mills, Commissioner for Nevada.—"3. Liver, boiled; when cool, grated in the trough; sour milk occasionally. 4. In State hatchery, 90 per cent.; we do not keep fry longer than three months."

Albert Rackow, Elmont, N. Y., private ponds.—"3. Beef hearts and minnows. 4. I lost seven out of 10,000. 5. I feed in troughs 6x12 feet and 8x24 feet." [See question No. 3.]

W. F. Page, Superintendent U. S. F. C., Neosho, Mo.—"3. Raw beef liver until 1½ inches long, which they get to be here in five weeks after taking food; then gradually mix mush of ship-stuff with liver. 4. Eighty per cent. 5. Yes, about five weeks."

J. W. Hoxsie & Co., private ponds, Carolina, R. I.—

"3. Pulp of sheep livers. 4. Eighty per cent. 5. Feed in troughs to six or eight weeks."

W. L. Gilbert, Old Colony Trout Ponds, Plymouth, Mass.—"3. Sheep livers. 4. Forty per cent. 5. Don't feed in hatching troughs."

Just before going to press these questions and answers were returned to the writers for correction after eight more years' experience, but none of them made any. A letter from Mr. G. Hansen, Osceola, Wis., March 26, 1899, says: "I feed fry up to one year old on beef liver and milk curd, mixed in the proportion of two parts liver to one of curd. I feed in troughs from February to May, sometimes until September, with good success, but prefer putting them in a nursery pond in May. The green slime, algæ, bothers me some in the hatching house by clogging screens, therefore I remove the fry. The wild fish give the best eggs."

COMMENTS ON THE METHODS OF FEEDING.

As a summing up of this question of feeding fry, let me say: There is nothing better than liver of beef, or perhaps other animals, from the start. Maggots are as good after the fish get big enough to swallow a full-grown one, and they do not drop until they are full grown. Trout in nature do not eat vegetable food, and while curd may be of value, I don't take a cent's worth of stock in any admixture of vegetable matter. Under my management of the New York hatchery on Long Island, the yearling trout, at twelve months old, measured from six to nine inches. No hatchery in the State could show such trout. This was partly owing to crowding the food to them and partly to the tempera-

ture of the water. Such results might be obtained in places as far, or farther, south, but never in the colder waters of the mainland of New York.

You cannot overfeed a young trout, nor offer it suitable food too often, and upon its growth during its first few weeks of feeding depends its future development. Once a dwarf always a dwarf; and the fry need to be kept growing from the start, like pigs, or they will never catch up to their better fed fellows.

Many fishculturists say, as Mr. Hansen does: "The wild fish give the best eggs." Then there is a fault in over or under feeding at the breeding season. Fish properly fed in ponds should, like other domestic animals, improve in fecundity and early maturity.

INTRODUCING NEW BLOOD.

This is a good thing in the breeding of cattle or fowls, but is not necessary with trout. With fowls and the cattle on the farm there is danger of in-breeding because the parents are so few, especially the sires. There was no such danger among the herds of buffalo and there is none among the trout in confinement. Take the eggs from 2,000 fish and fertilize them with the milt of 1,000 males; turn the progeny loose and breed from them two years later, and what are the chances of mating brother and sister? Even if this should happen, as it may, the same thing is purposely done by breeders of horses and cattle who are trying to produce the best stock.

It was my policy to keep the thriftiest fish for breeders, and in the twelve years that I ran the Long Island hatchery the yearling trout increased from a maximum

length of six to nine inches. That shows what breeding from the best will do in a short time. If you have two or three thousand spawners you need not fear degeneration from in-breeding. You have few chances of in-breeding. Suppose that six thousand persons, equally divided as to sex, settle on a fertile island. There is no chance for extensive in-breeding. Keep your own stock; breed from the best quick-growing stock, and keep out all outside wild blood as you would keep out blood from the wild boar among your improved pigs, and go on and develop a breed of trout that will be as far above their wild fellows as a setter is above a wolf.

If, however, you think you need new blood, don't get it from wild trout, but from some other trout breeder; exchange males with him as you would swap "roosters" with a neighbor.

The breed of trout can never be improved by reverting to wild stock. That fallacy has retarded trout culture many years. If your pond trout do not breed freely it is evident that you are not giving them the best treatment, either in food, flow of water, or something else that they lack.

GROWTH OF FRY.

Our trout on Long Island were a wonder to the men from other hatcheries—five to six inches in October and seven to nine inches at less than a year old—but the warmer waters of Long Island had something to do with this growth. No amount of food would produce such fish in the cold waters of the Adirondacks. A man who had a great reputation as a fishculturist about

the time I began told me that "water is never too cold for a trout, nor too warm for a sucker." He was wrong about trout, for they will develop faster in a temperature of 65° Fahr. than in one ten degrees lower; their life is more active and their digestions are consequently quicker, hence their growth is greater.

In its most southern habitat our brook trout excels its more northern kinsman, if food is equally plenty in both cases and if there is some depth to the water, for trout in mountain streams never grow large.

AUTOMATIC FEEDERS.

An automatic feeder would be a desirable thing, but a perfect one has not yet been found. When in charge of the American fishcultural display at the World's Fisheries Exhibition in Berlin, in 1880, I saw a German device to lift a gate and let out food at intervals, regulated by a water-wheel, but it dropped it all at the head of the trough, where the strongest fish got the first whack at it and grew stronger and more able to sustain their advantage. Then there was an arm on a universal joint which dipped a spoon into the food, carried it over the trough and spilled it.

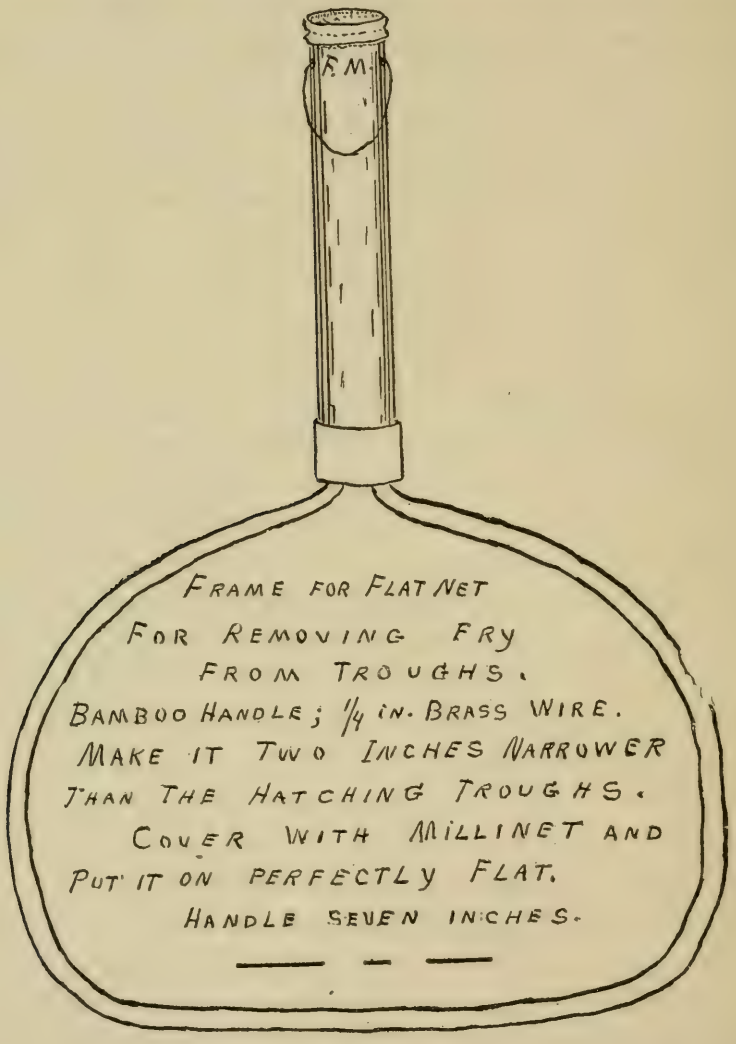
All these things are useless; it is the small fellows down at the lower end which need to be fed as well as the others; neglect of them means death or a stunted lot of yearlings. The fish in a trough must have an equal chance to get food, and any feeder which only feeds at the head of the trough is good for nothing. There is nothing like an intelligent man to do this work and to see fair play in all parts of a pond or trough.

PUTTING OUT THE BABIES.

In May the little fish should be put out in the sunlight and fed there. My rearing ponds were of yellow pine plank, 250 feet long, 3 feet wide and 3 feet deep, with water 2 feet deep, made of 2-inch plank on sides and 1-inch on bottom, nailed to outside frames. This stretch was divided into six compartments by double screens of No. 8 wire-cloth, 18 inches apart, with a dam between the screens that was 1 inch higher than the pool below. If fish passed one screen they might be dipped out before passing the next one, for the little fellows will get through a crack if there is one. The screens were to prevent crowding in any part of the long rearing pond and to facilitate feeding. The fish in the upper pool fared best, for in addition to liver they had the first pick of the small crustaceans which came in from the reservoir.

As the flow through these pools was about 600 gallons per minute, it was too strong for the little fellows all the time, and in a straight-away run a tired trout would be washed against the lower screen and die there. To prevent this there was a series of obstructions put in, which created eddies of rest for the weary. These were either alternate projections from the sides, as in some fishways, or with dams clear across, but with the top two inches below the surface; four inches below this was a dam extending from above the surface to six inches below it. This arrangement caused the water to flow up from the bottom, over the dam and to the bottom again, leaving comparatively still water in the upper part, and after stemming the strong bottom current for a while a fish could find rest above; it

also kept food swirling around, for there were eddies and not a straight flow, and it also kept the bottom clean. In the ten "baby ponds" of 24 feet long, as described, we put 8,000 to 10,000 babies in the upper



ones, leaving the three or four lower ones empty, but screened. The little fellows would get into these through cracks in the planks, loose screens or other

apertures, and then we would net them out and put them in the ponds above, for down stream were their yearling brothers, who would take them in out of the wet with pleasure.

In July they need assorting in order to keep the largest together, so that the smallest will have a chance to get their share of food, and the sorting should be done every six or eight weeks.

In September they are down into the yearling ponds and the yearlings let into the upper breeding pond, for we may get a few small eggs from some, which in November are twenty months old, counting from March of the year before.

CHAPTER VII.

STREAMS.

As a rule a stream has to be taken as we find it, but often it can be improved for trout breeding or for fishing. If possible, make it more crooked, with deep pools, fallen logs for hiding places and shade, cultivate alders or willows along the banks for shade and insect harbors, and, in fact, make as wild a stream of it, and one as difficult to fish, as it is possible, and you have done all that can be done to better it. Shade is loved by trout and it also keeps the waters cool.

If you contemplate draining a swamp where cool springs trickle all over, and think of making a trout stream of the collected waters, the farther you can get from a straight line the better. Nature always works

to destroy straight lines, and no natural stream ever ran straight; even if water is fond of making a short-cut, it is still fonder of following the line of least resistance, and will dig out soft banks and make curves.

If the banks are equally soft in a straight ditch where there is a good flow, the water will dig in at one side, rebound to the other, and so go back and forth until, if let alone, the stream will crook. See any natural stream coming down a level meadow—it is crooked.

A trout does not love a sweeping, continuous current in a straight stream, but prefers pools, shallows, rapids, and all the variations which occur in natural streams, where it can exercise in the rapids or rest as it chooses. The more difficult it is made to reach the banks, through vines and alders, and the harder it is made to cast the fly or to wade the stream, the better the fishing will be to experts, and the more the angler will enjoy the hard-earned trout he gets from it.

Moderately still places for spawning should be provided, and if there is no gravel in the stream, dump in several wagon loads at different shallow places, for if there is no gravel in your stream the trout will leave it in spawning time and seek gravel elsewhere, and your stream will be barren.

If it is a brawling mountain brook little can be done unless to deepen pools and make places where there will be eddies in times of freshets, so that the trout will not be washed out of their homes. Their tendency is to run up stream at such times, and they will do it if they can.

The following, translated for "The Literary Digest," shows the peculiarities of currents in streams:

"The phenomena exhibited by rivers are treated in an article in "Der Stein der Weisen," Vienna, June 15.

We reproduce the diagrams and give a translation of part of the text below:

" 'The most important factor in determining the current of a river is its speed, which increases with the fall and the quantity of water and diminishes with increase of the width of the channel. The speed varies also with the interior friction and with the friction of the water against the banks. . . .

" 'The result of this is that not all parts of the current along a cross-section are moving at equal speed. The velocity increases in a vertical direction from the ground toward the surface, but it is greatest not at the surface but a little distance beneath it; likewise it increases at the surface itself from the banks toward the middle. The lines of equal velocity in a cross-section take the form of half-elipses convex downward. It must be remarked further that the surface of the water is not horizontal, but sometimes convex and sometimes concave. It is the first in case a considerable mass of water with higher velocity (as at high water) moves in mid-stream, so that the middle of the river conveys more water than the sides. When the water is falling, a greater amount of water is flowing away at the middle, and the surface becomes concave. . . . In the Mississippi these oscillations of level measure as much as two metres (six feet).

" 'Owing to the shape of the bed of the stream, especially at the bottom, the water is deviated from a straight line, so that the line of greatest depth in the stream is curved. . . . If we observe the movement of the water from the banks to the middle of the stream we find that the water in the middle moves downward and then in a spiral path approaches first the bottom and then the bank.'

"The author next proceeds to describe the formation of eddies, the commonest case being illustrated in Fig.

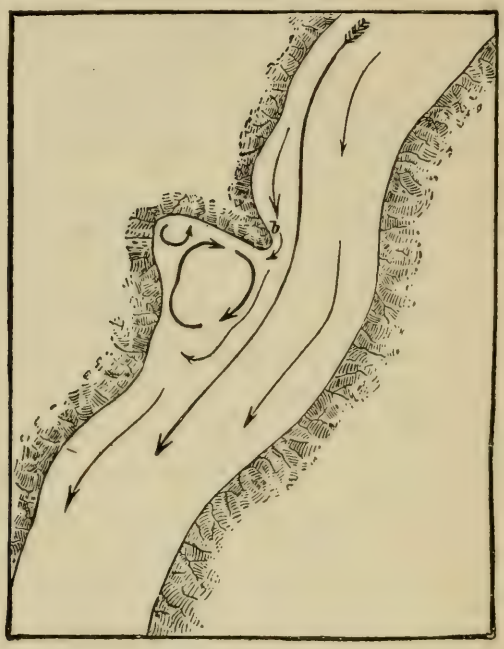


FIG. 1.

1, which needs no explanation, the direction and course of the current being represented by arrows. Fig. 2 shows a curious spiral motion of the water due to the fact that the current on the two sides of the channel sometimes moves with different velocities, setting up a tendency to form a series of eddies. Fig. 3 shows the formation of two kinds of eddies, one in front and one behind an obstructing point of land, which approaches so near to the opposite bank as to deflect the current noticeably, producing the phenomenon known in the Danube as *'Schwall'* (swell). Finally we have the continuous circling movements known as whirlpools, which require deep water and such conformation of the

banks as to direct the current in exactly the proper place for their formation. The article concludes with the following description of flood-phenomena:

"'In a swiftly flowing freshet the current at the surface is mostly in wave-motion. At the banks arise by reflection cross-waves which form with the others by interference of what are usually called "white caps."

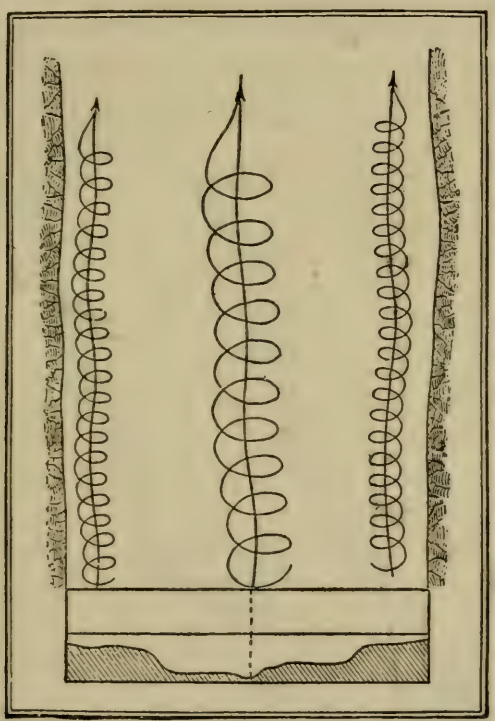


FIG. 2.

All the phenomena that appear during quiet flow are heightened in these times of flood—the eddies, the spiral movements, the whirlpools. Also the rapid wearing away of the sandy banks in places where the friction of the current is most powerful makes the whole proceeding evident to the eye.'"

CHAPTER VIII.

PONDS.

The first thing to be considered is the intention of the owner and what he wishes to do with his pond or ponds. He may want as large a pond as possible in which trout will feed themselves and afford him fishing for himself and friends, or to market some trout

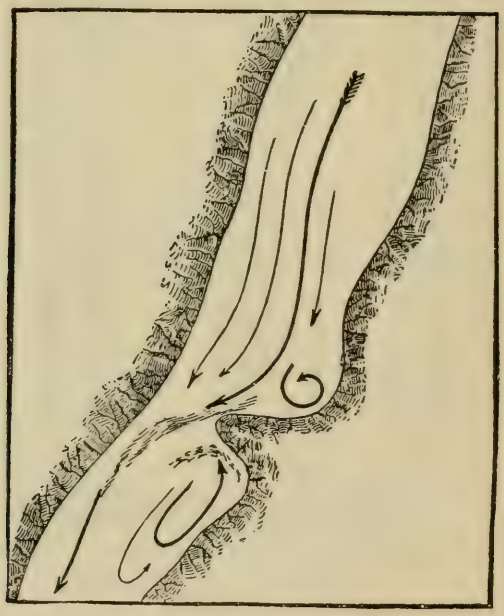


FIG. 3.

each spring. He may wish to have a hatchery and rearing ponds to stock his main pond with, or to have a series of ponds in which to grow trout on artificial food.

There are several ways in which trout may be culti-

vated, dependent upon the extent and character of the water and the inclination of the owner as to the amount of time he cares to devote to it, and the expense which he is willing to incur in beginning, which, as in most other affairs, bears some relation to the prospective results. With proper facilities, intelligent fishculture will prove as remunerative as any of the minor industries of the farm, such as bee and poultry keeping, but it is only very rare and exceptional places where it can be made a separate and distinct business which would warrant a person in devoting his whole time to it.

Where the spring rises upon a farm and flows some distance through it, with some fall and space to make ponds, the conditions are most favorable. It is very difficult to give directions for making trout ponds which will be applicable to all places, but it is safe to say that the very worst location and form for them is in a ravine where they are made by a series of dams thrown across. Such an arrangement is sure to come to grief, sooner or later, and if the dams are so strongly made as to resist an unusual flood from suddenly melted snow, or heavy rains, then the leaves and other riff-raff will clog the screens until the increased pressure carries them away and the fish have a chance to escape. The smaller the trout the more difficult it is to confine them, not only on account of their ability to escape through a small opening, but in consequence of their desire to continually seek that opening—a desire which is intense during their first year of life, but which decreases until it is so much diminished that large fish, of say three-quarters of a pound, can hardly be driven from deep water.

If only one pond is contemplated in which the fish are to be placed to seek their own food and care for

themselves, then it may be made as large as the stream which supplies it will admit of—that is, it must not be so large that the water will get above 70° Fahr., in the bottom of the pond. Depth will give coolness, or if there are springs in the bottom the fish will congregate there at the hottest times, while the warmer water at the surface and shallow edge is favorable for the production of insect life for their food. The stream above can be covered with gravel as a spawning ground, and the young will have a chance to escape being devoured by the larger fish by keeping in the shallows.

A pond of this kind was made at West Bloomfield, N. Y., on the farm of Mr. Stephen H. Ainsworth, a gentleman who was among the first to engage in trout culture in New York, beginning about the year 1858. He had a marshy spot of ground, formed by many small springs, whose united currents in the dryest times made a stream scarcely larger than a leadpencil; and digging this out he made a pond 50x100 feet, which was 16 feet deep, and covered over, where he raised many fish under great difficulties. In a dry season the supply barely equaled the evaporation, and no water passed from the pond; and on several occasions he lost his largest fish from the heat, until, in the year 1871, he removed the trout and substituted black bass. Yet he had accomplished enough to be an authority upon trout culture in that day, and is now quoted to show what can be done with little means, although I should never advise any one with only his facilities to make an attempt at trout raising. And the point to which attention should be directed is the ratio of depth to surface in his pond; if he had exposed more surface to the weather, or made his pond less deep, he probably would never have kept a trout through the first summer. In

cases of a rise in the temperature the large fish are the first to suffer.

LARGE SINGLE PONDS.

It is difficult to give directions which will be suitable for all places, but I will repeat that a dam in a ravine is the worst form. In such a place it seems better to make a small dam, and lead the water from it into ponds at the side of the ravine, and let the floods go down the old channel. My own ponds, at Honeoye Falls, Monroe County, New York, were made in a piece of low, flat land, with a plough and road scraper, using the earth, gravel, etc., taken out to fill up around the ponds. Afterward they were finished with pick and shovel, and a dry stone wall laid around them merely to hold the banks, but they were small, only 60x15 feet and 5 feet deep. The first one built was laid in cement, but was no better than the others. In some places there is muck enough to pay for the digging in manure; but if the water can be kept off, such ponds are not expensive. Here is the cost of one of mine of the dimensions above given:

Two men and team two days	$10.00
One man with shovel two days	3.00
Team and man hauling stone three days	10.50
Man laying wall three days	4.50
Screen boxes	3.00
Man one day ditching	1.50
Total	$32.50

The cost of stone was not added, as there was a quarry on the farm.

Naturally sloped banks of soil, sodded to below the water's edge, are best for all ponds over 100x200 feet, but surface water must be kept out. All ponds of the size named I call "large," because when we come to consider the "small ponds" of the professional fish-culturist it will be found that they are so narrow that every fish in them may be seen at all times.

The single large pond can only be worked to its greatest capacity by having a hatchery, taking and hatching the eggs, rearing yearlings and turning them out in the following spring after the water has been drained off and all trout of the previous year taken out, thus raising and marketing two-year-old trout each year, and a trout above that age is worth no more than any other fish, in market. See chapter on "Marketable Trout." All trout ponds should be drawn down once a year, or the trout will have a muddy flavor from decaying vegetation.

The bottom of the pond should be flat, if not level, and the fish should be removed with a net, instead of draining off the water to take them out. One of my mistakes will illustrate this: An original idea, one of those which so often come out of the little end of the horn, was to have a drain-pipe at the bottom of the pond stopped with a plug, and then make a deeper place in the centre, so that when the water was drawn off the fish would be all there ready to be dipped out with a hand or scoop net. What could be more handy? An improvement! After being in use three years it became necessary to take out the large trout and transfer them to another pond, and the water was drawn off. When about a foot was left the fish began to get alarmed and rush around, stirring up the water, which had appeared like crystal, until the motion of the fish

could be seen, and when drawn down as low as possible they naturally gathered in the pit, where they were dipped into tubs of clean water by a man in rubber boots. While in the pit they began to show signs of distress by keeping their noses out of the water, and the man who was dipping them said: "It smells like gunpowder." Then another idea, not original, dawned: the fish were being asphyxiated by the foul gas or sulphureted hydrogen!

The sluice at the inlet was opened, but too late. Out of the 2,500 fine breeding fish, only 39 were saved; they died even after being placed in fresh water while still breathing, and an expensive lesson in the dear school of experience was learned. I had seen the Southern darkies muddy ponds when collecting specimens for me, and knew that this gas, which lies at the bottom of all waters in which there is anything to decay, was a deadly poison if stirred, but the thought never occurred that the fish would do their own "muddying," as the darkies called it.

This experiment shows another fact: fish which feel secure in from three to four feet of water, and show no alarm at persons walking at the edge of the pond, and which will come readily to the surface to feed in your presence, or even take it from your hand, will, in water of not over a foot in depth, be as timid as wild fish just taken from the brook. Their sense of security is gone; hence it is better to take them with a net large enough to sweep the pond. It also shows what a little oversight or false reckoning may do toward sweeping away the results of expenditure and labor. In fact there is none among our domestic animals more difficult to manage, for the beginner, than trout, if they may be allowed to be domesticated; and their tendency to

go astray is excelled by the element in which they live, which is notorious for having a way of its own, which is never our way, and for seeking it at all times; hence in trout culture the great difficulties to be overcome are, to confine the water so that it is secure under extraordinary strains of flood and accident and to confine the fish—the latter being hardly as difficult as the former.

If the owner does not care to go into the business of hatching trout for a succession, as described, he should provide good spawning places such as are mentioned in the preceding chapter, and see that nothing molests the spawning beds in winter. In this way he may get a few trout which escape the old ones, which will keep them from becoming too plenty.

PONDS IN A SERIES.

In making a series of ponds in which fish of different sizes are to be kept and fed a different system is pursued, the ponds being made small, in order that the water may be changed quickly, and so sustain more fish, and the stock can be seen and its condition known at all times. Such ponds may be 50 to 60 feet long by 10 to 12 wide and 4 to 6 deep, with sides of clay, if that is the material dug through, stone, or wood. A spawning race should be made at the upper end, 20 to 30 feet long by 4 feet wide, the bottom sloping from 1 to 2 feet where it enters the pond; this will give the pond a shape like a long-necked bottle.

There should be a fall of at least six inches from the pond above into the spawning race, more if the lay of the land will permit, in order to aerate the water. For need of this see chapter on "Transportation of Fish."

The raceway should be covered with gravel at all times; for if the fish are not well, or are troubled with parasites, they resort to swift water and gravel bottoms to rub their sides and clean themselves. This gravel should be from half an inch to an inch or more in diameter.

In facing the pond with boards the pressure of the earth must be provided for, or the sides will soon fall in, or at least become badly bulged. To prevent this, lay timbers on the bottom and frame the uprights into them; nail the boards on the outside of the uprights, which should extend above the ground and be braced apart by joists running across the pond a foot or more above water. Even these will spring in time if not quite stiff. Ponds well built require but little work to keep them in order—an occasional stopping of muskrat or of crawfish holes, and in the spring to repair damage from frost, if any, or to patch up a bank or wall. There are hard soils where neither wood nor stone are needed (except on the spawning races, whose sides should be vertical), but may be made at a slope more or less inclined. Willows planted near the pond are valuable as shade trees, or floats of boards may be of use in keeping the water cool, besides being a sort of protection from the little kingfisher.

Perhaps an account of the way I made the ponds for the New York State hatchery at Cold Spring Harbor, Long Island, will be of interest, for they involved great labor. I took charge on January 1, 1883, and started work. An old building was used to hatch eggs obtained elsewhere, and there was a spring reservoir some 300 feet long by 20 wide, which had been made to turn a turbine wheel in the old building. This reservoir was high enough to bring water into troughs on the

floor of the second story, from where it went to the floor below and was again used. Some holes in swampy land below had been intended for trout ponds, but they were covered with water from the harbor at high tide and geese swam up to the hatchery.

The north side of the island is hilly, some hills being 200 feet above tide, and they are glacial drifts, sand, clay, gravel, etc., plowed out from the mainland by the ice. Such a hill was within 500 feet, and I filled the old holes with sand, leveling the swamp. Then "ponds" were staked out and left as the sand was dumped around them, on the principle that the Irishman said cannon were made; said he: "They take a long hole and pour brass around it." So we made ponds. These were temporary ponds, merely for use until the State could afford better, and the raceways were made of the cheapest hemlock boards.

In 1887 there was an appropriation for a new hatchery made at the insistence of Commissioner Blackford, and I planned to put it as high as the inflow from the reservoir would bear, as the water went from the hatchery to the ponds, and when it was up high we could control it. When the ground was staked out for the building the northwest corner was three feet above ground and the southeast was thirteen feet in the air. It looked queer, but the levels were correct. The foundation was built and I filled the grounds until there was no queer look about it. The old ponds were filled and new ones of sand built with their bottoms where the old surface was.

For a time it was dangerous to step near a pond, but it settled hard. Walks and flower-beds were laid out and a road made east of the ponds, which is as solid to-day as can be. The sand holds water well. The

carting of sand and gravel cost the State much money, but it is worth it. It is the most important hatchery in the State of New York to-day. I established the culture of smelts, lobsters and tomcods there, and if Mr. Blackford had not been removed from the Commission for political reasons I would have made a park of the place and have gone on with experiments in hatching oysters and clams. But a change of administration led to my discharge, and to-day a great unsightly ice-house stands in the centre of what was to be my "park," and there is a stable where a "conservatory" for water plants and the breeding of fresh water crustaceans and insects was planned; and my dream of a trout park and all its adjuncts is over. Blessed be the small-souled politicians, for they will never develop into anything greater!

DRAINS.

If the lay of the land permits it, there should be some way of lowering the water in order to clean the pond. If the pond is dug in the soil there should be a drain-pipe put in, and this, if of wood, may be stopped by a plug. But a plug is difficult to get out when the water is several feet deep; a box on the inner end with a sliding gate which can be lifted by a hook fitting into a hole is better. Do not plug the lower end of the pipe and leave the upper end open or you have a harbor for eels, water-snakes, or at least a hiding place for a large cannibal trout, for a trout of that kind prefers solitude. If the drain is a square box-trunk it may be turned up at a right-angle and used as an overflow stand-pipe, if the water is not required to be kept up for any reason.

In this case make a sliding groove for the dams, which may be lifted one by one, and are kept down by pins or wedges at the top.

Tile-pipe are not good for drains. I have laid them and relaid them many times, cementing them most carefully and then reinforced the joints with another coating of cement, but tree roots would force their way in somehow and either fill the pipe or break it. At Cold Spring Harbor, New York, I piped a spring from an upper level in six-inch tile-pipe, and it filled up with roots. In one case the root of a locust tree had found an entrance, and while only as thick as a sheet of letter-paper and half an inch wide where it went in, we took out thirty-seven feet of branching, matted roots, which nearly filled the pipe. Then I had the pipe relaid with extra care, but to no purpose; the roots would have water and knew how to get it, even where there was no leak. Here is a chance for a question about the habits of tree roots in their search for water; but having fought this "instinct" of roots for many years, I have given up trying to solve the riddle.

Remembering these things, when we obtained another spring to bring down I bought four-inch iron "soil pipe," caulked the collars with oakum and then ran lead around on the oakum. After this the lead was caulked, and the pipe will carry water for a century without interference from roots. This method, and pump logs, are the only means I know of to convey water underground without interference from roots, if there are trees near. A willow or a locust will send roots a hundred yards for water, if it is there, while on the other side of the tree the roots might not extend fifty feet.

It is said that iron-filings mixed with cement will

keep roots from the joints of drain tile. Having no experience with this, it is mentioned without comment.

DAMS.

These cannot be too carefully made to contend with pressure, leakage, muskrats, crawfish, frost and other things which are ever working to help water get to the lowest possible point. The following is from a newspaper which came after this chapter was begun:

NUNDA, N. Y., Jan. 30, 1899.—Miller's dam went out this morning. The washout, which resulted from undermining by muskrats, entails heavy loss to mill owners who have utilized the water. The disaster occurred at a time when the valuable ice crop was nearly ready to harvest. In building a dam, whether of earth, stone, logs or a combination of any or all of these materials, the greatest care must be taken to lay the foundation so deep that no trickle of water excavation, of muskrat or crawfish can go under it, and at the sides the dam should extend so far as to prevent such mishaps.

So much depends upon the nature of the ground and the materials to be used that it is impossible to go further into the construction of dams than to say: Make them about twice as strong as you think they need be and—then make them a little stronger.

SCREENS FOR PONDS.

Screens should be made at least ten times larger than the space required for the water. For instance, if the flow will pass through a hole six inches square, the

screen should be at the least calculation nineteen inches each way, giving 361 square inches, which will allow for some portions of it to become clogged, and yet pass the water through easily; this also diminishes the chance of stoppage by its slower flow. A good form for a small outlet is a trough, say six feet long by two feet wide and twenty inches deep, with a dam near the lower end about fifteen inches high. When the screens are placed in this, above the dam, slanting the top down stream at an angle of 45 degrees, it gives a good screen surface, the dam being placed at the height at which the water is to stand in the pond and the screen made to slide between slats. Great care must be taken in setting such a trough, if in earth, that the water does not work around and under it, or that frost does not lift it out of place; the former may be provided for by wide flanges, which make a sort of bulkhead and obstruct the direct passage of crawfish, earthworms or other borers, which, by starting a small leak, will soon cause a large one before its presence is suspected. To guard against upheaval by frost, in a climate where the brook trout love to dwell, is a more difficult matter; but my own experience on this point leads to a preference for light soils for tamping around the outlet box, instead of clay, which I first used on account of its resistance to water, but afterward abandoned, after a winter's fight with frost, in favor of a sandy, gravelly soil which was found to serve the purpose as well, as far as the frost was concerned, but which afforded excellent digging for the crawfish (fresh-water lobster) with which the stream was infested, and whose tunnels, once made in clay, never by any chance closed up; and, knowing their dislike to work in either sawdust or tanbark, a space of about a foot was filled with these materials so that there

was a barrier running around the box, backed in front and rear by soil which was thought to be the least affected by frost.

The screens should be made with as large spaces between the slats or wires as the size of the fish demands, and it will be found convenient to have the outlet boxes of the different ponds and the frames all of one size, so as to be readily interchangeable. The wires or slats for the fish of half a pound and over may have a half inch space between them, and for this purpose well galvanized iron wire is best, or, if not convenient, a screen can be made of planed lath, set edgeways; while for yearlings well tarred wire cloth of four wires to the inch is necessary, and for the fry during the first months at least fourteen wires to the inch. Screens for the inlets are best placed perpendicularly, in order that no trout may lie under them and shoot up stream when the screen is raised. The disposition of water to find its own way, and that way being always different from our way, combined with the disposition of trout, in their younger days, to prefer any location rather than that which we have provided for them, renders the subject of screens and appliances for confining them a very important one to the fishculturist, and one liable to defeat all his calculations and waste all his time, labor and money, if not properly considered. I have kept sharks and whales in confinement, and have seen the wildest of beasts and birds so kept, but of all animals that man confines there is none so uncertain to be found in the morning, where it was apparently so secure the night before, as a brook trout of an inch and a half long. It is an impossibility to confine them in a stream, and very difficult in a pond, as a crack or worm hole in a board, or in the earth or masonry, will be found by a hundred

little eyes, and its size tested by half as many heads; and if water flows through it, they are very apt to follow, no matter where it may lead, nor whether return is possible. The instinct of a trout impels it to jump at a fall or in going up stream, hence provision must be made to stop them from leaping over the inlet screen by a projecting board or other device, more especially in the fall of the year, when they wish to ascend to the upper waters to seek suitable places for spawning.

If the fry are kept for the first nine months or a year in "rearing boxes," it is not so hard to confine them as it is in the outdoor ponds, where the woodwork has to be fitted into the earth; and this system has its advantages, which are security of confinement, compactness, the ease with which they can be inspected and the larger ones removed from their weaker brethren, and the protection from bird, beast, reptile and insect enemies to which their relatives in the outdoor pond are exposed. To counterbalance these advantages, we have in the rearing boxes more care and labor, and less natural food. Still, if the labor can be given, it is the surest way, for the first three months at least, after which time they are better able to stand the exposure of outdoor ponds and avoid their enemies, which decrease in numbers with increasing size.

There is always one fence in summer time which detains the trout more effectually than any screen. This is the stream of warm water which the trout brook empties into, and, although they may seek its depths for food in winter after running down off the spawning beds, the first hint of a rising temperature sends them back to the cooler spring waters.

A good self-cleaning screen for large trout is a revolving cylinder of wire cloth. Make disks of eighteen

inches with four strips to stiffen the cylinder and cover this with No. 2 wire cloth. Run an axle through it and set it so that it will revolve in the current, with six inches of water to turn it; *i. e.*, set it in water to that depth. A half inch below the cylinder set a board edgewise under its centre, and all leaves and fine trash will be passed without clogging. This can be made to fit a trough or box. A coarse screen should be placed in front of it to catch sticks.

CHAPTER IX.

TEMPERATURES.

There are extreme temperatures which limit the lives of all things, animal or vegetable; and of all animals the fishes are the most sensitive to sudden changes. Water in lakes or streams is slow to change, and, while animals which live on land endure changes of a dozen degrees in twenty-four hours occasionally in our northern climate, it takes many days or even weeks to make such a change in running waters or in a large, deep pond. Even after the surface of a pond is frozen the water at the bottom will be found warmer than near the surface if the pond has much depth or if there are bottom springs.

I think our brook trout would prefer an even temperature of about 60° Fahr., equal to 10° Réaumur or to 13° centigrade. It ranges "from Maine to Dakota and north to the Arctic Circle and south to the Chatta-

hoochie river" (Jordan). But in the southern portion of its habitat it is confined to streams in the Blue Ridge and is not found in the warmer waters of the low lands or near the coast.

About 70° Fahr. = 17° R. or 22° Cent. is the limit of heat that a brook trout will endure; although if the flow be very strong they may stand it for a little time, but will suffer and die if the water does not cool soon. On a cloudy, damp day a trout will live longer on land than in water of 80° Fahr.

Our lake trout cannot endure as warm water as the brook trout can. It has its limit at about 65° Fahr. For the rainbow and the brown trout it has been claimed that they will endure water that is slightly warmer than brook trout can stand, but I am not prepared to affirm or deny the claim, never having submitted then to the test.

Ice on a trout pond will do no harm if the pond has a circulation of water through it, but a shallow pond with no flow that freezes entirely over, leaving no air holes, is a deathtrap for fish of any kind. Such ponds are common along the upper Mississippi, being merely holes where the high water leaves many fish. I once chopped through the ice on such a pond and there was a powerful odor of dead fish; they had smothered.

CHAPTER X.

FOOD FOR ADULT TROUT—MUSSELS.

At Cold Spring Harbor, N. Y., I made trial of many kinds of food for both adult trout and fry, in order not

only to find the best food but also the cheapest. I began with the old standard food, beef livers, but they were only to be had from New York City, thirty-two miles by rail, as no one butchered regularly in that part of Long Island. Then we tried the black mussels, *Mytilus edulis,* which we boiled for convenience in opening, and the fish appeared to thrive on them for a few months, when some sloops came into the inner harbor loaded with mussels for the city market, and so cleaned up the crop that my men could not make it profitable to collect them any longer. These salt water mussels attach themselves to rocks, timbers or any stationary object, and were plenty. They hang in crowded bunches, which can be gathered in great numbers. The gray mussel was not so plenty there and is not eaten by men, and I can't speak of it as fish food. I made a mussel shucker, which worked well. It used to take a man half a day to cook and open two bushels of these mollusks, and, believing that something could be devised to do the work quicker, I made a cylinder of wire-cloth of three-quarter inch mesh, with wooden ends, and hung so as to be revolved by a crank. A door in the netting admitted the boiled mussels and a few revolutions dropped the meat into a box below, leaving the shells in the cylinder. But the usefulness of the "mussel jerker," as the men termed it, was cut short by the loss of the mussels, as related.

SOFT CLAMS.

Then we tried the soft clams, or manninose, *Mya arenaria,* both raw and cooked. We liked them and the fish took them well, but our yield of eggs was scant that fall, as there were more barren trout than usual.

Whether this state of things was caused by the food or not is impossible to say, as it was tried only one season because the neighbors complained that we were taking too many clams from the harbor, and we stopped. A bushel in the shell weighs 64 pounds and the raw meat 16 pounds, but when boiled they only weigh 8 pounds.

HORSE MEAT.

There was a "knacker" a few miles away who killed old or injured horses, sold their skins, bones and hoofs, and said that he disposed of the meat to the kennels, of which Long Island has several; but "Frenchy" still had meat to sell, and I bought it free from fat and bone at four cents per pound. It was fed from November, 1891, to September, 1893, twenty-two months, and long enough to form the opinion that fed raw, as we fed it, we did not want any more of it. The trouble was that it was not easily digested, as shown by the long streamers of white fibre which trailed behind the fish. Again we were short in the number of eggs which the trout should have yielded, and some fish had died from inflammation of the lower intestines.

Then I found a man in New York City who would furnish me beef livers at four cents per pound, and changed back to the "old reliable."

BEEF LIGHTS AND MAGGOTS.

At Honeoye Falls, N. Y., in my first trials, I fed beef "lights," as the lungs are called. They were fed raw and cooked, but were indigestible and showed the same white "flags" that horse meat did. Then I tried mag-

gots. Boxes or nail kegs, with slat bottoms, were suspended over the ponds, and in these the lights and other refuse meat was suspended. The flesh flies blew it and maggots hatched, grew and dropped into the ponds when the time came for them to go into the ground to enter the pupa stage. It was a perfect food, the trout taking it readily and growing finely, but there was the objectionable odor. As the ponds were not near my house, the smell was not so objectionable to me, but there were many visitors, mere curiosity seekers, who complained. But this was not the only reason for its abandonment. Swarms of great carrion beetles, over an inch in length, came and either ate the meat, the maggots, or both, and I concluded that there should be more maggots per pound of lights and meat than I was getting, and I abolished the "maggot factories."

Some years ago Mr. Charles G. Atkins, superintendent of the United States salmon hatching station at East Orland, Me., fed maggots, but he had his "factories" on top of a hill and brought down the product in pans or boxes. I think he used smaller apertures and excluded the beetles.

Lest any one doubt the excellence of the larva of the flesh fly, which we term "maggots," as fish food, I will cite the fact that English anglers, who call them "gentles," scour them in bran for a day or two and use them as bait for several kinds of fish, and Izaak Walton speaks of his "box of gentles."

FISH.

The flesh of fish, such as fresh-water chubs and suckers, or salt-water kinds which have little or no value

in market, are used with good effect and are one of the natural foods of trout.

HASLETS.

"Sheep's haslets" are used east of New York—and that is a New England name for what New Yorkers call "plucks," meaning the heart, liver and lungs all attached to the windpipe as it is removed from the animal.

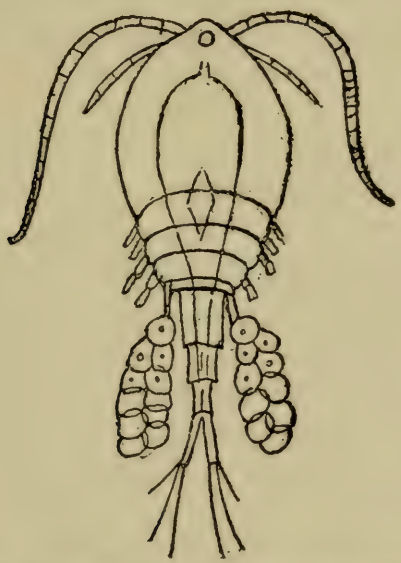
NATURAL FOODS.

If the fish are to forage for the whole or part of their food the pond should be stocked with such water plants as grow in spring water and then the crustaceans, gammarus and asellus should be introduced. But beware of

GAMMARUS (magnified three times).

the burrowing crawfish, for it not only enters into competition with the trout for its crustaceans and insect larvæ, but makes holes in dams. Besides this, it cannot be eaten by small trout when it is in the adult state, and when soft it hides. The gammarus is usually called

"fresh-water shrimp," while the asellus, or "water asel," looks somewhat like the "sowbug" found in decayed wood. In some waters these crustaceans grow to the length of three-quarters of an inch, but usually they are smaller. Trout also eat newts or salamanders as well as snails, both the spiral and the ramshorn. Insect larvæ will be apt to breed in the ponds without being especially introduced. The gammarus is greatly over-



CYCLOPS, with eggs (magnified 40 diameters).

rated as trout food. A few are eaten, but not in the proportion that is usually thought. My searching of stomachs of wild trout under two inches long showed, under the microscope, that Cyclops and Daphnia, two minute forms barely visible to the eye, were the most plentiful.

On Wilmurt lake, situated on top of a mountain in Herkimer County, N. Y., where no fish but brook trout

live, I opened the stomachs of 247 trout that had been dressed for the table. No microscope was at hand, and there was much that could not be identified. From what was distinguishable a rough estimate was made. It was: Insects and their larvæ, 80 per cent.; newts, 15, and gammarus, 5.

At Meacham lake, Northern Adirondacks, the result from 138 stomachs was: Insects and larvæ, 60; newts, 5; gammarus, 5; fish, 30. Therefore, I feel warranted in ranking the gammarus low in the list of trout foods. Still it has a value. Trout of a pound weight seldom eat it.

HOW THEY FEED IN JAPAN.

I have been visited by several Japanese gentlemen who are interested in fishculture. M. K. Ito, of Hokado Cho, Sappora, came here twice, and at the Centennial Exposition in Philadelphia, in 1876, I often met Mr. Schizawa Akekio, attached to the commission of that country. Speaking several European languages with remarkable fluency, his desire to become acquainted with the methods of American fishculture was only equaled by his perseverance. Returning to Japan, he at once set to work to establish fish hatcheries, and in 1877 fish stations were made at Yuki, Kanawaga, Shirako and Saitama Ken, each of them with the capacity of raising 30,000 fish. The number of these fishing establishments has of late been increased. The largest hatchery is at present at Shigaken. As cattle are never butchered in Japan, it became quite impossible to feed the young salmon on liver. Mr. Akekio, with a great deal of ingenuity, substituted the chrysalides of

the silkworm, mixing them with flour, and he writes me that after having used this food for four years, he finds that the fish thrive on it remarkably well. An analysis of this food shows that it contains nitrogen substance in abundance, besides a suitable quantity of oily matter. It seems that the Japanese, for the last 200 years, have employed a method for propagating salmon by letting them spawn naturally and confining this reproduction to a fixed locality.

In the River Tenegawa there is a natural spawning bed some 1,200 yards long by 50 wide. A fence is made above, and after the salmon ascend another fence is thrown across the stream below. After the fish have been inclosed for a week, their eggs become naturally fertilized, and the parent fish are caught. Another lot of fish are allowed to enter, and so the process is continued.

Mr. Akekio states that in May, a year afterward, the healthy young fish go down to sea. The profits from the river must be large, as it supports, by netting the fish, some 750 families. Our most intelligent Japanese fishculturist has been in receipt of some McCloud River trout eggs, sent to him by Mr. B. B. Redding, Fish Commissioner of California, in 1877, and other species sent by Prof. Baird. Great difficulty was experienced at first in finding water of a right temperature, as the weather was warm, and there was no ice; still, in the face of a great many obstacles, 1,000 fish were saved. "From 1877 till the present time," Mr. Akekio writes, "the fish have grown satisfactorily, and their average weight is five pounds, and their greatest length one and a half foot." Both Japan and Germany are indebted to the United States for practical lessons in fishculture, and so far our American fishculturists have not been obliged to go abroad to learn their business.

PATENT FOODS.

I have tried two kinds of patent food, or rather that of two makers, who put up food for dogs and pheasants. In both cases it was dried and full of small, sharp bone. A trout can digest a soft fish bone, but pieces of the skeleton of an ox or horse are a different matter. As they could not give me the meat free from bone we did not do much business.

The following is from a circular:

"Fine all-meat fish food, specially manufactured for feeding fish from the time the young fry are hatched. Used with the greatest success at the Caistor Fish Farm, Lincolnshire, England, and at many other places. Manufactured in five different grades—Nos. 0, 1, 2, 3 and 4. No. 0, finest ground for feeding young fry in the boxes, up to two months old; No. 1, for feeding fish from two to five months old; No. 2, for feeding fish from five to eight months old; No. 3, for feeding fish from nine to twelve months old; No. 4, for feeding big fish.

"*Note.*—No. 4 should be soaked before it is given to fish. Nos. 1, 2 and 3 should not be soaked, but simply thrown lightly on the water. The fish will take the food as it gradually sinks to the bottom. Fish should not have anything coarser than No. 0 for the first two months after they are hatched."

The food smells rancid, and the floating qualities of some of it let it go to the outlet uneaten. As this food appears to be made from a whole horse thrown into a grinder, of course the bone cannot be separated. The bone is good for poultry, but is too sharp for the intestines of a trout, young or old.

WHAT OTHERS SAY ABOUT FOOD.

In 1891, with this book in mind, I sent out a circular which contained eight questions regarding trout culture. As the answers relate to different chapters, I will divide them. Most unfortunately, I put two questions in one—(No. 7)—which asked: "If you breed trout for market, do you find that it pays; and if so, what do you feed the adult fish and at what cost?" Many fishculturists, especially those connected with the Government or State hatcheries, merely replied: "I do not raise trout for market," and let the main question go unanswered.

Here are some answers:

"I feed on shrimp and branch minnows, suckers, carp, etc."—E. M. Robinson, Superintendent Mammoth Springs Hatchery, U. S. F. C., May 26, 1891.

Albert Rackow, Elmont, Long Island, N. Y., says: "I feed my trout on beefs' hearts and minnows; growing 8,000 trout every year, and it pays a profit."

W. L. Gilbert, Old Colony Trout Ponds, Plymouth, Mass.—"Yes, it pays. We feed sheep's plucks, which cost about one cent per pound at the hatchery."

G. Hansen, Osceola Mills, Polk County, Wis.—"There is no money in feeding trout to two and three years old and then sell them for 50 cents per pound in the markets. It pays better to build bigger ponds—say one to five acres—where the fish can get natural food, and then have sportsmen come and fish for them, at say 25 cents per pound. In this case there is no food to buy and sportsmen near by can board with the proprietor. I had fishermen here who took in this way, in one day, 150 pounds of trout, and paid us at the

same time for board. If a pond is handled in this manner I think there is money in it."

CHAPTER XI.

PLANTING FRY.

The proper time for planting fry is just previous to their first taking of food; in other words, before the yolk sack is entirely absorbed. Just as they begin to swim from the bottom upward they should be removed instanter. It will not answer to wait longer, as the first hatched will become emaciated and weak, and if they do not die in transportation they will not try to secure food and will soon perish. Numerous failures in restocking depleted streams are attributed to keeping the fry too long in the hatching troughs. The most satisfactory results will always be obtained by planting the fry, when they have arrived at the proper size, in suitable waters, where there is an abundance of natural food, and here their instinct of self-preservation will develop the same as in fish that are hatched naturally.

I write this strongly, as I have steadily opposed feeding the fish and planting in the fall as "fingerlings," or the next spring as "yearlings," by the State Commissions, on account of the expense being greater than the advantages. The planting of yearlings has been advocated for the past eight or ten years and many papers

have been read on the subject before the American Fisheries Society.

It may be possible that one yearling trout, having escaped enemies of small size, is as good as ten fry. Admitting this to be true, for the sake of argument, then I say plant the ten fry, because it is cheaper to do so, if you are to put out a million or more for some State or Government hatchery. At the South Side Sportsmen's Club, at Oakdale, Long Island, N. Y., they feed their fry until they are yearlings, remove the screens and let them find their way to their lakes. They have a fishculturist and one or two assistants, who have little else to do, and the expense is only for food. Under the same circumstances I should do the same, while planting some fry in the head-waters of their many miles of streams. But, when in charge at Cold Spring Harbor, there was danger that the State Fish Commission would order me to feed fry to yearlings and plant them, and to do this would take money needed for new ponds; and my only way to prevent this was by an indirect appeal to them not to enter upon such a wasteful course by papers read at the American Fisheries Society, and no yearlings, except a few salmon, were planted from that station while I was in charge.

Having called it a wasteful way of planting fish from a State hatchery, it follows that I should prove the charge. A man would leave the hatchery with ten ten-gallon cans of fry, 5,000 in each can, for streams up the Hudson, and be on the way twenty-four hours, often more. To take 5,000 yearlings—and many of our yearlings were 9 inches, 23 mm., long—would require him to make five trips, for ten cans is about all a man can attend to on a long trip, reckoning fifty cans

with 100 yearlings in each. When you multiply his railroad fares, freight, cartage and wages by five there is more expense than profit in the transaction. A trip which cost $25 would run up a big bill for five trips, and extra men would have to be put on the road. If you have long trips to make, plant fry, and, if necessary, increase your hatching capacity as many times as may be needed. Nature plants fry enough to keep up the stock if man does not interfere.

I think the yearling heresy was started by Mr. Frank N. Clark, an old personal friend of mine, but with whom I have usually differed on minor points in fishculture; but even Mr. Clark has said that he could not rear all his fry to yearlings because of the expense. Then the late Col. McDonald, United States Commissioner of Fisheries, got the yearling craze and hammered at everybody who did not agree with him. He was an irritable, autocratic man, who could not bear to be opposed, and no one in his employ dared suggest a better way of doing anything. To illustrate this let me quote from the First Annual Report of the Commissioners of Fisheries, Game and Forests, of the State of New York, for a portion of the year 1895, page 14: "Four years ago the late Colonel Marshall McDonald, then United States Fish Commissioner, writing to one of the staff of this Commission, said of one who was an ardent 'fry' man (*i. e.*, one who believed in planting helpless fry as soon as they were ready to feed): 'If he chooses to attack the policy of the United States Fish Commission in planting yearling fish, it will simply stamp him as unprogressive and past his period of usefulness.'"

This might mean me, or it might mean the Hon. Herschel Whitaker, of the Michigan Fish Commis-

sion, who stood, and still stands, with me on this question. Just why the New York Commission saw fit to quote this personal matter I have no opinion to offer.

STOCK HEAVILY.

At the close of 1898 I wrote the following for the "English Fishing Gazette":

"I believe in stocking heavily. Ten thousand trout fry to a mile of stream filled with chub and other fish are as good as wasted. Make it 100,000 fry or 10,000 yearlings to the mile, and then watch the result. If you do this in some fished-out streams with the two American species named above, you may hear from them."

To this my friend Whitaker wrote to know if I had abandoned my stand on planting fry, as he saw that I recommended planting "100,000 fry or 10,000 yearlings." My reply was that, as some people will plant yearlings, I wrote in that way, and asked him to look at the New York Report above quoted, saying to him: "We did not attack McDonald's policy; it was he who attacked ours; and I do not consider healthy trout fry to be 'helpless' if planted at the heads of streams."

TIME TO PLANT FRY.

Fry must not be planted or taken any journey in wagons or by rail until the sac is so nearly absorbed that they can sustain themselves in the water and have

lost all disposition to lie on the bottom of the can, where they are liable to be killed by continuous shocks and bruises. Until the sac is nearly gone they cannot bear handling, but they grow stronger as the umbilicus is absorbed.

In taking fry, as well as adult fish, great care must be taken of the two vital points—temperature and aeration. The temperature may be kept down by ice, or, better yet, snow, for ice, if in large pieces in the cans, will crush many fish, while snow is soft; an ice tray in the top of the can is best.

As the trout exhaust the oxygen from the water more must be supplied. This is done in several ways; by using a dipper and pouring the water a foot or more through the air; by drawing off a pailful through a siphon which has a strainer of perforated tin or of cheese-cloth in the upper end, and then pouring it back and forth in another pail a few times and returning it to the can. With ten cans these ways are too laborious, while an air pump is useless unless you have a fine strainer in the bottom to divide the air and keep it from coming up in large bubbles, which do little good, and the labor is too much. I prefer such a brass syringe as greenhouse men use for spraying plants, with a fine "rose" sprinkler on the end; one and a half inches in diameter and twelve to fourteen inches in length. This is lighter and easier to carry than any of the other implements and is as effective; fill the cylinder, raise it a foot above the water and drive the fine streams down into the can. At a temperature of 40° Fahr., three injections to each can every half hour when not moving should keep the fish at the bottom, for when they are suffering for air they will crowd to the surface for it. When they do this it will take continuous work for an

hour, and hard work, to get all the fish in ten cans down to the bottom again and breathing easily. Never let them get to the top; treat them to an aeration every half hour by the watch, or oftener if they need it, but never let them suffer for a moment.

When the water is sloshing about on a car or wagon, have no more water in the cans than can be carried with the covers off, and they need not be worked more than once in an hour or two if the water is cool. Take extra care when standing still for an hour or more; there is then more danger of suffering.

At the place of deposit compare the temperature of the brook to that in the cans by a thermometer, and if there is a difference of three degrees Fahr., set the can in the brook, adding a little brook water occasionally; take an hour to this if necessary, and when you are satisfied that the fry will not be injured by the shock from a warmer or colder temperature, lower the mouth of the can and let them swim out. After all your trouble and expense you cannot afford to dump your fry in a hurry and trust to luck to their living through a shock. This is why I always preferred to send one of my own men to plant fry to having the owner of a stream come for them. No doubt millions of good, strong trout fry have been killed by the "dumping" process of some unthinking or ignorant man who thought: "Here's the brook and there's the fish; dump 'em in." A man may be a very learned man and not know how to plant trout fry.

In 1872 I submitted a plan for aerating water by pumps worked by a band on a car axle to Prof. Baird. This was afterward used by Mr. Stone in his aquarium car, and was no doubt again originated by him, for it was naturally the first plan that would suggest itself to

one about to transport live fish on such a long and perilous journey, as he had undertaken to transport fish from the Atlantic to the Pacific coast." The above I wrote for "Rod and Gun," and it appeared in its issue of February 26, 1876.

In 1874, with Mr. A. A. Anderson as an assistant, I tried to get 100,000 shad fry from Holyoke, Mass., to Germany, and failed. An account of this will be found in the chapter on "Shad."

CHAPTER XII.

TRANSPORTING ADULT FISH.

The main things in taking live fish on railway or other journeys have been explained. We get oxygen from air, and fish get the same thing from water. A submarine diver can stay down long if air is pumped to him; if it stops, he dies from the carbonic acid gas which his own lungs throw off. The case is the same with the fish. They are shut in a can where no oxygen can reach them except what comes to the water through its sloshing about in the motion of the car, if the cover is left off, or such as you may give them by syringe, air pump or other mode of aeration (see chapter on "Transporting Trout Fry").

The next important point is temperature. If the fish are taken from icy water, or from spring water in winter, you may ice them heavily; but if you are taking fish from a pond in summer, say black bass or perch,

do not reduce the temperature more than ten degrees or you may have either dead or barren fish in your ponds. The aeration of water, as before described, is like pumping air to the submarine diver—it means life.

Large fish should not be sent in circular tanks, because they will crowd to the side, which closes one gill cover and prevents the other from closing; hence they cannot breathe well and may soon die.

Twenty pounds of trout will live four hours in twelve gallons of water if under 40° Fahr. Two pounds of trout will live for four hours in three gallons at 40°.

SECTION II.

OTHER TROUTS AND THE SALMONS.

America is rich in species of *Salmonidæ*. We have the *Salmo salar,* with its variety *Sebago,* which is the only salmon of our east coast, and is identical with the salmon of the west coast of Europe. Excluding the whitefish and its relatives, we have of salmons chars and trouts—and we call all our chars "trout," the following salmons, *S. salar,* on the east coast. On the Pacific coast we have *Oncorhynchus chouicha,* the quinnat or chinook; *S. gairdneri,* the steel-head or salmon trout; *O. nerka,* the redfish, blueback or sockeye; *O. keta,* the dog salmon, and *O. kisutch,* the silver salmon.

Of chars we have *Salvelinus fontinalis,* the eastern brook trout; *S. aureolus,* the sunapee or golden trout of New Hampshire; *S. namaycush,* the lake trout east of the Missouri River; *S. oquassa,* the blueback trout of Maine, and *S. malma,* the dolly varden, bull trout and western char, of the Columbia river basin and other waters of the west.

Of true trouts we have *Salmo irideus,* the rainbow trout; *S. fario,* the brown trout imported from Europe, and *S. mykiss,* the "cut-throat" trout of the west—fourteen species, and all of them of value, more or less, except the dog salmon, which is eaten only by Indians.

CHAPTER XIII.

THE SALMONS.

As all that has been said of the breeding of brook trout is applicable to the salmon, there is little to be added under this head. The eggs are larger than those of trout and do not differ much in size, while in color they are of a beautiful "salmon" shade.

The United States has a good salmon breeding establishment at East Orland, Maine, where parent fish are obtained from the Penobscot; but in Canada and New Brunswick there are larger ones, which have done grand work, despite the opposition of some ignorant fishermen, who imagine that the hatcheries injure them in some way. In Norway, Sweden, Germany and other countries the salmon is artificially cultivated on a scale more or less large, but our neighbors to the north lead the work in this industry.

THE PACIFIC SALMONS.

Not more than three of the Pacific salmons are of much value. The best is the "king," or quinnat salmon, *Oncorhynchus chouicha,* and then comes the little "blueback" and the "steel-head."

The quinnat salmon was introduced into our eastern waters for a number of years by the million, and distributed in the rivers from Maine to Texas, and not one adult was ever caught on the Atlantic coast. In this case the failure was not due to light stocking, but

to the absence of melting snows in early summer, which in the short Pacific streams affects the temperature at the mouths of the rivers. On Sept. 10, 1899, one weighing 10¼ lbs. was taken in the St. Lawrence River near Cape Vincent, and identified by Mr. Livingston Stone.

The "land-locked salmon," as it is miscalled, is not shut in by land, and can go to sea if it wishes, but has for some reason lost this migratory instinct. In all respects except migration they are identical with *S. salar.* Mr. Charles G. Atkins has charge of the United States breeding station at Grand Lake Stream, Maine, and has stocked many suitable waters in different parts of the country.

There is a tendency now to give this fish its Indian name of "winninish," some clinging to the French spelling of "ouannanish;" but if the French have no letter W in their language, we have. They spelled Wisconsin "Ouisconsin," but why should we do so? Let us call it "winninish," and spell it so in a good English fashion.

The winninish has thrived when it has been planted in deep, cool lakes. From the New York "Sun" of May 13, 1890, I clip the following:

"HAMMONDSPORT, N. Y., May 12.—Lake Keuka was stocked with land-locked salmon fry four years ago. No evidence that the fish had prospered in the lake was developed until last season, when Trevor Moore caught a two-pound specimen of the salmon near the inlet of the lake at Hammondsport. Others were caught at different points along the lake, in each case while the anglers were fishing for other fish. A few days ago Frank Costerline was fishing for bullheads near the inlet of the lake, and caught three very large land-

locked salmon. A fourth, the largest of the lot, was hooked, but broke the line and escaped."

CHAPTER XIV.

OTHER TROUTS.

BROWN TROUT (*Salmo fario*).

And now I write of a fish which is a naturalized citizen, but, being a recent importation, has not taken the rank among us which it will work up to in future years. Confidence is said to be a plant of slow growth, and so is reputation. Recently Mr. R. B. Marston, editor of the London "Fishing Gazette," said that he believed the brown trout, *Salmo fario,* to be the best trout in the world. I agree with him.

Those who believe that nothing can possibly come from Europe which may excel any native product, and allow prejudice to shut out all things not indigenous to America, will, of course, object to this statement. Let us compare the handsome char which we call "brook trout" with its kinsman, the brown trout, which is not a highly colored, fine-scaled "char," but is in the genus *Salmo*—a coarser fish, if you will, but a grand one.

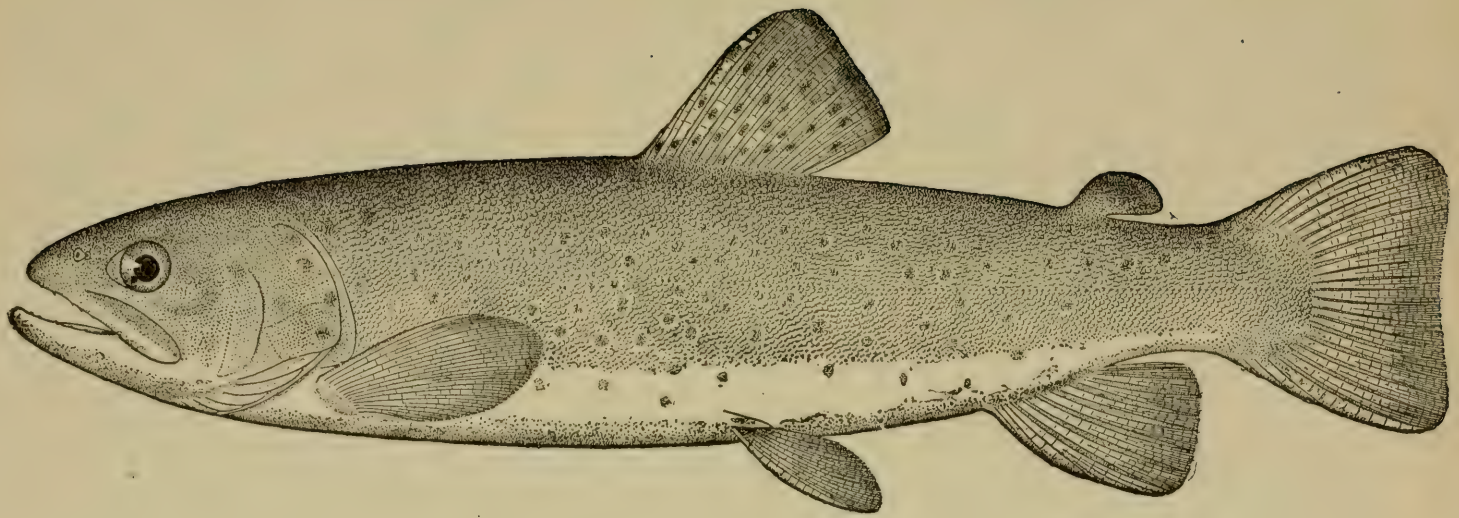
In support of this opinion I will quote an article from my pen, written in 1887, in the Bulletin of the United

States Fish Commission, entitled "Brown Trout in America":

"In July, 1886, Mr. Frank J. Amsden, a banker, of Rochester, N. Y., sent to Mr. E. G. Blackford, of Fulton Market, a brown trout which weighed, on its receipt, three pounds. It was taken in Allen's Creek, Monroe County, New York, a tributary of the Genesee River, which receives the famous Caledonia Creek, on which the hatchery of the New York Fish Commission at Mumford is placed. This fish must have been one which was hatched at the Caledonia station in March, 1883, from eggs sent there by me. These eggs were the first which were received in America, and came to me as a personal present from my friend, Mr. von Behr, President of the Deutscher Fischerei-Verein, whose headquarters are in Berlin, and consequently the fish was about three years and three months old.

"At the time that these eggs were sent from Germany Mr. von Behr advised me that there were two kinds of them, not species, nor even varieties, but merely from different waters. One kind, the larger eggs, were from trout inhabiting deep lakes, while the smaller kind were from the mountain streams. These kinds are probably analogous in respect of size to the *fontinalis* of the Rangeley Lakes of Maine and those of our other eastern American waters, as near as I understand the case. I sent to the Caledonia station eggs of both kinds, and this fish, which was taken in Allen's Creek, is probably one that escaped from the hatchery, unless a plant had been made in the creek.

"In the ponds under my charge at Cold Spring Harbor, we reserved some of these first importations, but lost the greater portion of them from various causes. Of the few that were left there was one which was



BROWN TROUT (*Salmo fario*).

somewhat larger than its fellows, and proved to be a male fish, and was named 'Herr von Behr,' in honor of my German friend. In October, 1886, when it was three and a half years old, we took it from the pond and placed it in an aquarium in the hatchery, which had a good flow of running water, in order to show it to the New York Fish Commissioners, who were expected the next day. In the morning the fish was dead, and it now reposes in alcohol, where its size can be admired by visitors. Its weight was three and a half pounds plump, or at any rate of one pound a year."

Mr. A. D. Frye, of Bellmore, Long Island, writes, under date of March 27, 1887, as follows: "Two years since I applied to you for some brown trout to stock a public stream, called Newbridge Creek, at this place, and you furnished them. I have by inquiry learned that last summer some of these fish were taken which weighed three-quarters of a pound." According to this, these fish could not have been more than one and a half years old; and from my experience I think that the brown trout, as it is called in England, and which is the common brook trout of Europe (*Salmo fario*) is a quick-growing fish, which is destined to become a favorite in America when it is thoroughly known. I have taken this fish with a fly, and consider it one of the gamiest—in fact, *the* gamiest—trout that I ever handled with a rod.

I believe that the brown trout will be found to be a better fish, taking it all around, than our own native *fontinalis*. The reasons for this belief are: (1) It is of quicker growth; (2) it is gamier; (3) except in the breeding season, when the males of *fontinalis* are brilliantly colored, it is fully as handsome; (4) from what I can learn I incline to think it will bear water several

degrees warmer than *fontinalis,* and therefore it is adapted to a wider range.

In the winter of 1882-3 I introduced the brown trout, *S. fario,* into America. The eggs were sent to me as a personal present by the late Baron von Behr, President of the German Fishery Association. I had taken the fish in the Black Forest, Germany, and had told Herr von Behr that, if opportunity offered, I would introduce it in America. Some years later (January, 1883) I was appointed to start a hatchery on Long Island, and he sent me something like 100,000 eggs, most of which were good. I had not time to prepare for their hatching, and sent some of the eggs to Mr. Clark, Superintendent U. S. F. C., in Michigan, and some to Mr. Green, at Caledonia, N. Y., who, like myself, was a State superintendent of a hatchery. Mr. Clark publicly acknowledged this present of eggs, but Mr. Green, who never could admit that there was more than one fishculturist on earth, gave it out that he imported the eggs and took the liberty of calling them "German" trout. He had a way of giving new names to fish, deriving them from some locality, such as "California mountain trout," "Oswego bass," etc., which have mostly died out. The unfortunate prominence which the newspapers gave him retarded fishculture some years, through his antagonism to Prof. Baird and all other fishculturists. "Top rail or no fence" was the motto, and as he was a "pioneer," he had the backing of ignorant editors. He was a man of brains, but newspaper notoriety was his weak point.

GROWTH OF BROWN TROUT.

Some anglers have objected to the introduction of

brown trout in our streams because they grow too fast and might eventually kill out our native fish. To this I say: "Let 'em do it if they can, and the 'fittest' will survive;" but they can't do it. The chubs, dace, pike, bass and other fishes have worked this game for centuries before a white angler wet a line in an American trout stream, and here we are! A trout is a cannibal when he gets to be three years old, whether he is a native American or an adopted citizen, and it is only a question of which fish matures in the shortest time for the angler.

A Rochester paper said: "A brown trout was taken in the spring brook below the Caledonia hatchery on June 1, 1891, by F. P. Brownell, which weighed eleven pounds, and as the first importation was made in 1883, by Colonel Fred Mather, it could not have been over eight years old, at most. Brownell would say nothing of the mode of capture, and offered to sell it for two dollars. Failing to sell it, he took it home, and was preparing to cook it when Mr. Annin dropped in and saw it. Commissioner W. H. Bowman has said that he would have given ten dollars for it to send to Washington to have a plaster cast made of it, and other men would have been glad to purchase it for scientific purposes; but it is fortunate that Mr. Annin saw, identified and weighed the fish. Brown trout have been taken in England weighing as much as eighteen pounds, but this one is the largest on record in America at present writing."

The so-called Loch-Leven trout of Scotland are the brown trout, which differ slightly in color in their native waters, but show no differences when hatched in America. Sir James Ramsay Gibson Maitland, Bart., sent many eggs from his great fish breeding establish-

ment at Howietown, near Stirling, Scotland, but when grown the fish could not be distinguished from brown trout.

Dr. H. G. Preston, President of the Oxford Rod and Gun Club, whose preserves are at Eastport, Long Island, wrote me under date of March 29, 1891, as follows: "Brown trout eleven and twelve inches long were caught last April and May, the growth from the fry you sent me the year before." This beats any growth that I know of. This club moved from Patchogue, some sixteen miles west, to Eastport in 1889, but had no fry from us until the next year; therefore the age of the fish could not have been over thirteen to fourteen months—truly a marvelous growth.

The following from ex-Commissioner, the late Gen. R. U. Sherman, is of interest as showing that brown trout have grown and bred in the Adirondack waters; not as large as elsewhere, and this is not surprising, for those cold waters do not grow fish as quickly as more southern ones where the temperature ranges well into the sixties for over half the year:

"NEW HARTFORD, N. Y., Nov. 13, 1890.—DEAR SIR: We have been taking at Bisby lately, in our spawn gathering, quite a number of what I suppose to be *Salmo fario,* and have already put on the trays 10,000 eggs. Some of the fish are of two pounds weight, but the general run is from one-half to one pound. We planted in Bisby lake 5,000 of the *S. fario* fry, and these fish, I suppose, are from that plant. Three or four years ago we planted in a small spring pond flowing into Bisby 10,000 fry of Loch-Leven trout from eggs courteously furnished by you. The fry were very hardy and vigorous, but we never saw one of the fish

after the fry were put in the pond. It is possible the fish we are now taking are Loch-Leven, which have come down from the little pond to the lake.

"Very truly,

"R. U. SHERMAN."

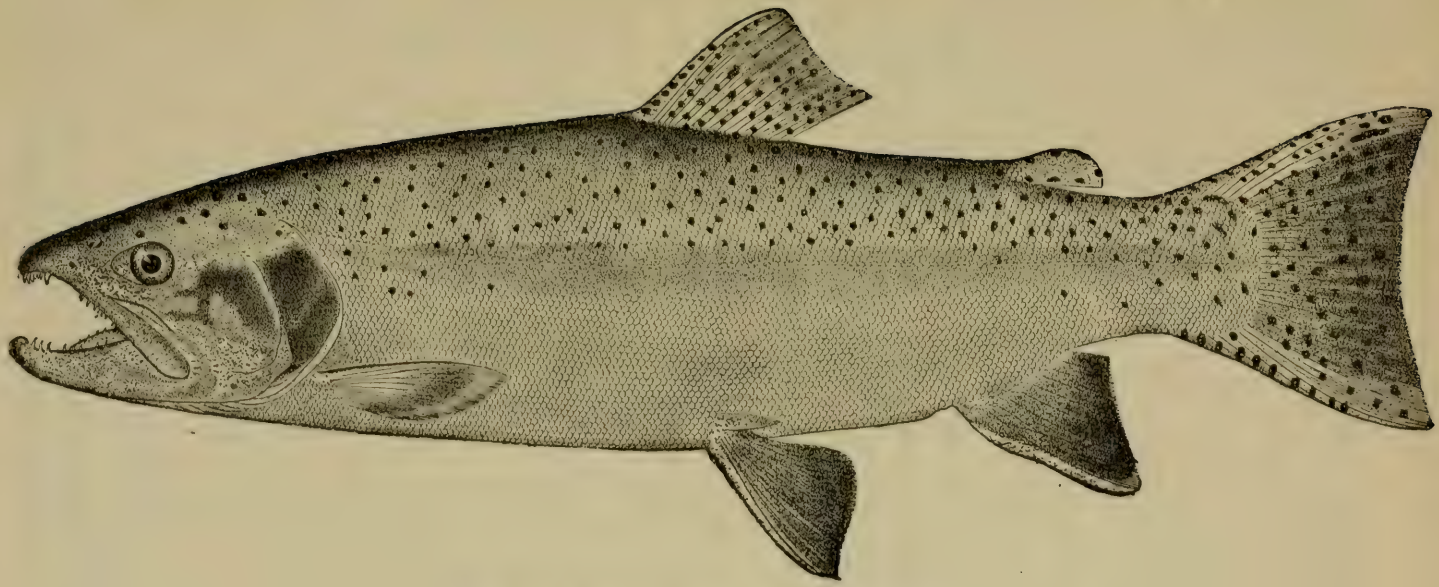
I have, in another place, said that the brown trout and the Loch-Leven trout are the same fish, and so, too, wrote Gen. Sherman.

RAINBOW TROUT (*Salmo irideus*).

This handsome fish, which is a native of the Pacific coast, in the mountain streams of California and northward, was introduced into the eastern waters by the United States Fish Commission in 1880, but some years before that date the late Seth Green brought some adult fish to his ponds at Caledonia, N. Y., and bred from them. As usual, he gave them new names, for he claimed to have two species, calling them "California brook trout" and "California mountain trout;" but he knew nothing of ichthyology and could not describe the differences, which, by the way, did not exist.

This fish is a "true trout," as has been said. It has a very small mouth, for a trout; is black-spotted, with a wide crimson band running along each side. It will bear slightly warmer waters than our "brook trout," and therefore may be of use in a more southern habitat. They are not as great fish-eaters as other trout, and this is another point in their favor. In deep waters, notably those of the Ozark region of Missouri, they have grown to a weight of ten pounds.

"Rainbow trout will live in warmer water than brook



RAINBOW TROUT, male (*Salmo irideus*).

trout, and are found in swift, rapid streams at 85° Fahr., especially where there is some shade; but in ponds that temperature is dangerous, even with shade and a good current. In its natural condition this trout is usually found in water varying from 38° Fahr. in winter to 70° Fahr. in summer, and in selecting a site for a trout hatchery spring water with a temperature of 42° to 58° is required. The rainbow trout is a superior game fish, a vigorous biter and fights bravely for liberty, though in the east it is somewhat inferior to the brook trout in these respects." The above was written by Mr. George A. Seagle, Superintendent U. S. F. C. Station, Wytheville, Va., for "A Manual of Fishculture," published by the U. S. Fish Commission in its Report for 1897—pages 1 to 340—and afterward as a separate book.

When the fish was first brought east all the fishculturists disliked it, myself among them, because its eggs were not readily impregnated, and when one has to pick out 50 to 75 per cent. of eggs he finds it more work than he wants. It spawned in very early spring or late winter, as one chose to regard February and March, and many of the eggs were hard and "glassy;" these declined to receive the milt, being already full. This condition we now know to be due to the eggs being over-ripe and absorbing water somehow before extrusion, as they will not readily spawn in confinement for some unknown reason.

THE RAINBOW IN ENGLAND.

Mr. R. B. Marston, editor of the London "Fishing Gazette," asked me the following questions:

1. Has the rainbow trout become established in any eastern coast rivers; *i. e.*, to breed freely in a wild state?

2. Has it been good friends with the other trout, or has it taken so much interest in them as to eat 'em up?

3. Does it rise well and freely to the fly?

4. Does it stop in the rivers where planted?

5. Is it better than salmon to eat?

To this I answered as far as my knowledge of the fish went, and in his issue of August 27, 1898, he printed the following from my pen:

"You evidently want a monograph on *S. irideus,* but I am not competent to write it, for I've never fished west of the Rockies, and do not know this fish in its native waters. A review of your questions shows that you only want to know about it in the east, and I'll try to answer.

"1. Not that I know of. The rainbow has been bred in the State of New York for about twenty-four years. Most of my books are in storage, and I must not try to give exact dates, but it was about 1873 or 1874 that Seth Green took young shad to California and then introduced the rainbow trout in the east. He turned them out indiscriminately, and I stocked many streams with them as a superintendent under orders from the Board of Fish Commissioners of the State, but I do not know of a stream where they have become established, in the sense that you mean. Adults are caught here and there, but I do not know of a stream in which they have sustained themselves; but their propagation goes on. They have been planted in the State of New York, from the cold mountainous lakes of the Adirondacks to the most southern streams of Long Island. I will refer to this question again, after the others are answered categorically.

"2. I doubt if the rainbow is as destructive to small fish as either the brown trout (*fario*) or our own *fontinalis.* This doubt has two foundations. In confinement it has shown no disposition to eat smaller fish if other food was plenty, and its comparatively small mouth bars it from taking some fish that a *fario* or a *fontinalis* could easily stow away.

"3. Yes; it rises to the fly well. I stocked the upper of three millponds at Cold Spring Harbor, Long Island, with rainbows, and when fly fishing below the second dam two years later I took a number of rainbows. Mr. Livington Stone, for years in charge of the breeding station at Baird, Cal., where the fish is native, says they rise well to the fly.

"4. This may be a matter of suitable water. My own experience has been mostly with confined fish. In its native rivers, of course, it has been true and faithful, but in our eastern rivers there are different conditions. The fish has remained in some Adirondack lakes and grown large; but whether it has bred there and 'established itself' I cannot say. This is 'the benefit of the doubt.'

"5. This is a question of taste, *de gustibus,* etc. The rainbow is a good table fish; but it is a trout, and I can't compare it to salmon any more than I can compare a saddle of Southdown mutton to a beefsteak. The rainbow trout is hardly as good a table fish, *me judice,* as the brown trout, or our 'brook trout,' and any one of the three beats salmon as a steady diet in camp, for salmon is so rich that it soon cloys. This is merely an individual opinion, but it is what you asked for.

"Having gone over the questions in their order, I feel inclined to say more. I have seen the articles in 'Land and Water' of March 26, by yourself, Mr. Charles S.

Patterson, M. B., M. R. C. S., F. Z. S., and the notes by the Editor. As Sir Lucius O'Trigger says: 'It's a very pretty fight as it stands.'

"Mr. Patterson is correct in the main, but assumes that the 'steel-head salmon' (*S. gairdneri*) is a salmon, a natural mistake to make from its popular name. It is a big river trout, so very like the rainbow in structure and markings that at one time some ichthyologists thought them the same fish.

"Since our favorite *fontinalis* has refused to stay in English streams, the fact that *irideus* may not have established itself in waters of the State of New York is no proof that it may not be good in yours. Most Americans think that *fontinalis*, the char which we call 'brook trout,' is the best trout in the world. It is, in its home. On Long Island and in Canada, where it can, it goes to salt water, and comes back plump and in excellent order, but its red spots gone if it stays there long. Then in Canada it is called 'sea trout.' In the trout streams of the Hudson river it is barred from the sea by the warm water of the river in summer, and in winter it does not want to go down.

"When I was engaged in fishculture all our fishculturists disliked the rainbow trout at first because its eggs did not impregnate well, and we had to pick out about 75 per cent. of unfertile eggs. This is not so now. Then the fish had been taken from waters which were colder in the spring, when the snows above the short streams west of the Rockies melted, and it was a spring spawner, for all *Salmonidæ* spawn on a falling temperature. Gradually the rainbow changed its habit, and began to spawn earlier, until now, after some twenty or more generations of breeding in the east, it spawns in the fall or early winter. If you get more

rainbow eggs, get them from Eastern America, where the spawning habit has been changed from spring to early winter."

My answers were not satisfactory to myself; they hinted that I was not certain about question 1, and I asked Mr. Marston to send me galley slips. These I sent out, and the answers show that I did not know it all. Here they are:

Hon. Herschel Whitaker, of the Michigan Fish Commission, one of the most able and enthusiastic of fish-culturists, writes:

"Regarding the questions which you wish me to make some suggestions about, will say, so far as query 1 is concerned: We have had considerable experience with this fish in our State, and a somewhat peculiar one. Several years ago we began stocking streams, and after a few years became utterly discouraged because of their non-appearance, and became convinced there was no use continuing the work and quit it, liberating the stock fish we had in a water near by the hatchery. In the course of a few seasons we were astonished to find that in some of our better rivers the rainbow was showing up magnificently and spawning. The fish soon became so popular with sportsmen that we again secured a stock of fish, and have since been stocking waters to which they take kindly, which are our larger streams, that afford deep pools, where they seem to remain most of the year, although in June and July many small rainbows are taken on the riffles. It is now thoroughly established in several of our rivers, and is the fish all anglers are looking for. Its edible qualities, in my opinion, are not to be compared with the brook trout, but he is a fighter from way back.

"So far as its being good friends with the brook trout

is concerned, I am inclined to think he is a very good friend of the smaller brook trout—in fact, takes him in whenever opportunity offers. I think big fish that are piscivorous prey on other fish at all times when possible, and the rainbow is no exception in this regard. One of the most successful bait fishermen I know fishes much for the rainbow, and his most tempting and successful lure is the chub or shiner; so there is no question as to the rainbow's proclivities in this regard. As to question 2, I should say he did rise most magnificently, especially from 5 o'clock on to 10 P. M., during July and August—and then you have trouble if he is a big one.

"Answering query 4, will say that it does stop in suitable streams, and is apparently content with its surroundings."

Mr. Frank N. Clark, Superintendent of the U. S. F. C. stations in Michigan, writes from Northville:

"In response to your letter under date of February 4, in reference to rainbow trout, and in answer to question No. 1, I would say that the Au Sable and the Pere Marquette rivers of Michigan are well stocked with rainbow trout. One year ago last fall I had a camp on the Au Sable River for the purpose of getting a stock of brook trout eggs, and upward of 10,000 spawners were secured; and at each haul we would catch from 500 to 2,000 rainbow trout which were hatched out the spring before. In the Au Sable, then, the presence of rainbow trout in large numbers has evidently been established. The Pere Marquette River is practically the same, and there are other streams in Michigan where rainbow trout are quite plentiful. They seem to stay in the Michigan streams and do not go out into Lake Michigan. Large quantities, however,

are found away below the point where brook trout are, and during the spawning season, which begins about February 1, they go up stream, and all the way between Wakeley's Point and Stephan's Point (which is a distance of about seven or eight miles) they make beds for the purpose of spawning."

Mr. W. de C. Ravenel, of the U. S. F. C., says:

"In response to your letter with reference to rainbow trout in streams of the east, I regret that I cannot give you as definite information as I should like. I presume that by the east you mean streams east of the Sierra Nevada—that is, streams in which the rainbow trout was not indigenous. Commencing with Wyoming, I would refer you to the reports of their State Commission, which show that rainbow trout are numerous in several streams, as a result of plants made by their State Commission and by the United States Commission. At one haul of the seine hundreds of fish from three to eight pounds in weight have been taken. In Colorado the rainbow trout is thoroughly established in various branches of the Platte River, also in Twin Lakes and a number of other lakes. In the Ozark regions of Missouri and Arkansas numbers of streams have been thoroughly stocked and the trout are doing well. In Iowa, Mr. R. S. Johnson, the superintendent of our station there, reports the collection of adult rainbow trout in several streams. In Michigan, in the Au Sable River, trout weighing from five to seven pounds are frequently taken. The Au Sable many years ago was a grayling stream; but rainbow, brook and grayling are now caught in the same localities.

"In Eastern Tennessee, in the Jack River, rainbow trout are thoroughly established, and are reproducing; and in a number of rivers in North Carolina the same

conditions exist. M. C. Toms, of Hendersonville, N. C., on February 6, 1896, wrote us with reference to the success attained in Green River from fish planted from the Wytheville, Virginia, station. Mr. J. D. Phipps, of Longs Gap, Grayson County, Virginia, reports Peach Bottom Creek as splendidly stocked, fish having been caught there measuring twenty-two inches in length. He speaks of them as fine game fish, and reports that the increase in numbers has been great. Mr. W. K. Hancock, writing from Colorado, makes the following statement: 'In the streams throughout this part of the country rainbow trout are not very plentiful, and their average size would be from three to five fish to the pound; but occasionally one will be taken weighing from one-half to three-fourths of a pound. Their growth is very slow in our streams in this immediate vicinity (Leadville); in the lower part of the State, south and southwest of this, they are more plentiful and grow much larger. In Twin Lakes, twelve miles southwest of here, they grow to twelve and thirteen pounds. They are very game and are considered fine table fish.'

"A correspondent, Mr. T. W. Scott, of Rome, Georgia, under date of December 17, 1895, reported that numbers of rainbow trout were caught in Silver Creek. William W. Finney, of Belair, Maryland, in a letter dated April 26, 1895, refers to two streams flowing into the Susquehanna River that were stocked some years before. He states that several had been caught in the stream after all hope had been abandoned of their being found, and that besides the large fish numbers of small ones were observed, from four to five inches long. Mr. Atkins, last spring, in a tributary of Alamoosook Lake, near East Orland, Maine, captured 199 adult rainbow

trout which had ascended the stream for the purpose of spawning. These were the result of fry liberated in this lake some years before.

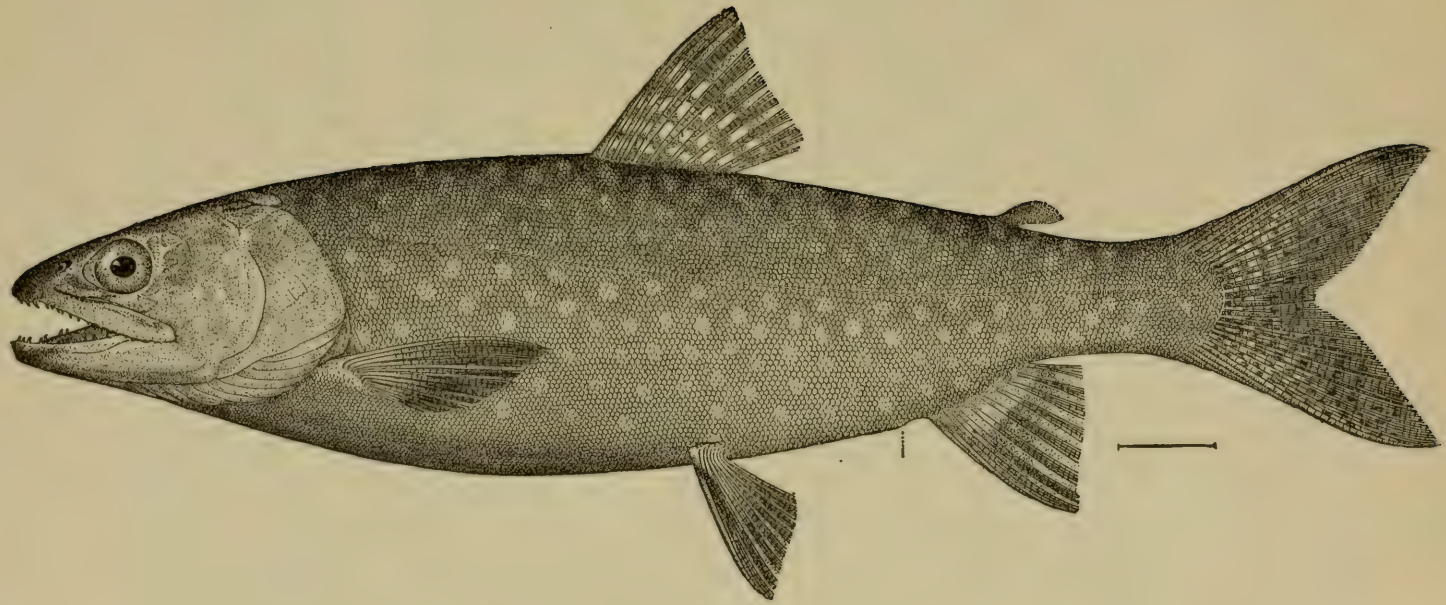
"In addition to the information given you, by reference to the Commissioner's report for 1896, pages 136 to 139, you will find some data on this subject, collated by Dr. Smith. I am also under the impression, without being able to give you the exact figures, that the rivers and streams in the State of Wisconsin have been very thoroughly stocked."

Other letters of like tenor were received from Mr. John G. Roberts, Superintendent of the New York State hatchery at Saranac Inn, in the Adirondacks; Mr. W. F. Page, Mr. W. E. Meehan, Assistant Secretary and Statistician of Pennsylvania Fish Commission, and others; but enough has been cited to show that the rainbow trout has come east to stay.

LAKE TROUT (*Salvelinus namaycush*).

This species is gray-spotted, the spots sometimes tinged with red. Its caudal fin is deeply forked. They require colder water than the brook trout, and in the summer they are only found in the deeper waters of those lakes which have a depth of forty or more feet, and have large springs at the bottom. The lake trout is not much of a favorite with anglers because it must be fished for in such deep water, and its fighting qualities are inferior to those of the brook trout.

The "salmon" of the Adirondacks, which one hears of so much, is simply the lake trout, sometimes called salmon-trout, and often the first part of the name only is used. But they are not salmon nor salmon-trout.



LAKE TROUT (*Cristivomer namaycush*).

A lake trout of 27¼ pounds, from Raquette lake, is credited to Alvah Dunning, the guide, who sent it to the Superintendent of the Adirondack railroad. It was taken July 2, 1879.

Most people agree on the excellent table qualities of the Adirondack lake trout. They are a fine fish, and I prefer them, when small, to the brook trout for the pan. In the spring, while the water is cool near the shore, these fish take the fly, but in summer they must be sought in deep water, for, like all deep water trouts, they are sensitive to warmth and die soon from it. The sabling, or German char, is probably as sensitive, and our deep waters would suit it very well. The fish would also suit the waters, as it is a lake trout of large size with a beautifully colored crimson side and belly, and a fine table fish. The native trout of the Adirondacks can be distinguished from those planted by the Commission from parents in Lake Ontario by their color. The skin is darker and the flesh redder, yet ichthyologically they are the same fish. One would think the strangers, having been placed here in babyhood, would assume the characters of the natives.

There is a variety called "siscowet" in Lake Superior which is shorter and "inordinately fat," a very doubtful distinction.

As the brook and lake trout often occupy the same spawning grounds at the same time, there would be danger of mixing the breeds but for the fact that brook trout spawn in day time and the lakers at night, and the milt of the male fish loses its power of impregnating eggs in less than five minutes after extrusion.

CHAPTER XV.

HYBRID FISH.

All the salmonidæ readily hybridize. As an experiment in the study of animal life it was worth while to try this, but in ordinary fishculture it is a very bad practice, for no possible good comes from it in the culture of trout. This was such a fad at the New York State hatchery at Caledonia that when the present State Fish, Game and Forest Commission took charge of the work they found but few pure bred trout of any kind in the ponds. For years bastard fish had been bred indiscriminately at that station and sent out into the streams. The new Commission wisely stopped this work and stocked up with pure bred fish. No such thing was found at Cold Spring Harbor when I left it, for I would not have a bastard fish; I hate the name, even if softened to "hybrid."

At Mr. Blackford's "trout openings" I have seen trout from Caledonia marked "One-sixteenth brook trout, nine-sixteenths lake trout and three-eighths salmon." Fishculturists who know how difficult it is to keep young trout from being mixed during the first year used to smile at the very specific amount of each kind of blood which involved some bookkeeping for several years.

SHAD AND ALEWIFE.

I have hybridized the shad and the river herring, alewives, in great numbers, but there was a valid reason

for it. At the last haul at night, on the Hudson, we often got a lot of spawning shad, but no males; the net would have a lot of ripe alewives, and it was a question whether it was not better to fertilize the eggs than to throw them away. The bastards would be eatable, and so, on that ground, the hybridizing was done. The eggs hatched, but I never say an adult fish which I thought to be the result of this cross, and I worked the Hudson many years.

The fishermen learned of this, and when they caught a mattowaca, as the Indians called it, the "tailor herring" (*Clupea mediocris*), which was in the Hudson centuries before they were born, they named it "Rebel shad," as they first noticed it shortly after the Civil War.

SHAD AND STRIPED BASS.

Green claimed to have crossed the shad with the striped bass, and the Hon. Robert B. Roosevelt, then (1879) President of the New York Fish Commission, wrote a long article on the subject for the New York "Tribune," dated October 3, 1879. To many persons a fish is merely a fish, and they would see nothing strange in crossing one kind on another; but fishes differ in structure as mammals do, and the man who should claim that he had crossed the dog and the cat, the horse and the cow, or the sheep and the goat, would be laughed at. Animals must be nearly related to interbreed, and when you cross the horse and the ass you get a mule, an infertile hybrid. The dog and the wolf may have issue, but the dog and the fox will not, although a case or two has been reported.

The shad with its soft fins and serrated abdomen

differs from the striped bass with its spiny fin-rays and hard scales more than the dog differs from the fox or the cat, and as much as the horse differs from the cow. The water where Mr. Green was hatching shad may have been filled with milt of shad; his bass milt may have fallen on barren soil; his eggs may have hatched, and as he turned the fry loose he may have honestly believed that the fish were the hybrids that he claimed them to be, but I do not believe it.

Since writing this a correspondent of "Forest and Stream" asked some questions which were referred to me. At the risk of repeating, I give his questions and the answers.

"1. How far can hybrids be produced among fishes? 2. To what degree are they fertile, either with one of the parent stocks or with each other? 3. Do hybrid fishes occur in a state of nature?"

Answer.—1. No man knows how far hybrids can be produced among fishes, because comparatively few fishes have been bred artificially, and of these the experiments in hybridizing have been mainly confined to the salmon family. We know that animals must be closely related to hybridize, and that few hybrids are fertile. The wild "Canada" goose will breed with our tame geese, but the progeny is infertile with either parent or among themselves. The same is true of the horse and the ass, which can produce the useful mule, without which our armies would be impotent, and who "without pride of ancestry, or hope of posterity," threw his weight into his collar and pulled the artillery out of the mud. Horses would have fretted to death at this time, but the mules chewed a splinter from the neck-yoke, received a lash that cut in deep, heard the objurgations of the driver, and the battery went on.

Animals near together often refuse to breed or produce infertile progeny, called "mules"—for the term is applied to all infertile hybrids, such as crosses between the goldfinch and canary birds, and is not restricted to the hybrid animal which serves our armies as neither of its parents could do. The hybrid geese referred to are "mules;" that term simply means an infertile hybrid.

To question No. 2, I can only say that most of the salmon family appear to produce fertile hybrids, as far as the trouts and salmons are concerned, but no experiments have been made to my knowledge with the different whitefishes, smelts, etc., which "belong" to the family by reason of some such slight affinity, such as having the second dorsal fin composed of fat instead of rays.

To the third question I will say that I never knew hybrid fishes to occur in nature. All animals prefer to mate with their own kind. Nature abhors a mule, and limits it to one life, with no progeny. I have known a wild mallard to mate with a black duck and raise a brood, but the birds were wounded and could not fly, and they had no choice. This was on the Pamunky River, Virginia. Some men regard every animal which they are not acquainted with as a hybrid. When the grayling was first brought to notice in America, a man wrote to a sportsman's paper giving it as his opinion that the grayling was a cross between a trout and a sucker, and that man was a fish commissioner of Illinois at the time.

CHAPTER XVI.

BARREN TROUT AND ANNUAL SPAWNERS.

Occasionally we find a female trout which has no eggs at the spawning time. Many of these I have opened; some had the little cluster which promises a crop next year, but three had no sign of ever bearing eggs. The fish had not spawned or the flabby sides and swollen vent would have been present, and there was no indication of these conditions. I paid little attention to this matter until I received a letter from Charles A. Hoxsie, Carolina, R. I., where trout are raised for market. Under date of Jan. 21, 1889, Mr. Hoxsie wrote a letter, from which I quote:

"In the fall of 1887 I took some trout from my natural pond, where they had been about a year, with plenty of natural food. This pond has four acres in it. On Oct. 1 they were put into a spawning pond, and when the time came for them to go on the spawning races I got spawn for a few days when not a trout would go on the beds. Upon examination there were no eggs in them, and I thought they must have deposited their spawn. I kept these fish until last fall, when I again put them in the spawning pond, and the same thing happened.

"A careful examination showed that nine out of every ten were barren, no eggs in them, nor had there been any, and I concluded that they were barren the year before. This is a new thing to me, and I would like your opinion. Have you ever heard of such a thing?"

My answer was that I had seen barren trout and had

some, but they were not fish that had been moved at spawning time nor were a large proportion in any one pond barren—just a few individuals here and there. (See chapter on "Feeding Adult Trout.")

When I sent out my circular to trout breeders to get their ideas question No. 8 was: "In your experience do you find that a female trout spawns every year?" The answers were varied. Here are some:

"Usually I have found a few exceptional cases of barren females."—Livingston Stone.

"Yes, with very rare exceptions."—W. L. Gilbert.

"Can't say."—W. F. Page.

"I think they do until nine years old."—E. F. Boehm.

"I do."—Monroe A. Green.

"No, the brook trout especially."—E. M. Robinson.

"Some certainly do, as we find in the Adirondacks. Two large deformed brook trout come to the same bed and spawn every year."—J. G. Roberts.

"When healthy and sufficiently fed, not overfed nor underfed, I think they do. Insufficient food will retard the development of the eggs. I am certain that overfeeding as the breeding season approaches also has a bad effect."—R. O. Sweeny, Duluth, Minn.

The evidence in the case shows that some trout may be permanently barren, while others may skip a year now and then or be biennial spawners, as some claim the salmon to be. It would be interesting to clip off the little adipose dorsal fins from all barren trout and see if they spawn the next year or if they are permanently barren.

SECTION III.

OTHER SALMONIDÆ.

The salmon family includes other fishes than the salmons, chars and trouts. This is not the place to go into the common characters of the different genera and species, but we may say that a few of these characters are an adipose second dorsal fin, stomach siphonal, with 15 to 200 pyloric appendages; no oviduct. The genera are: *Coregonus,* the white fishes, seven species, and *Thymallus,* the graylings, perhaps three species. Once the smelt was included, but is not now.

CHAPTER XVII.

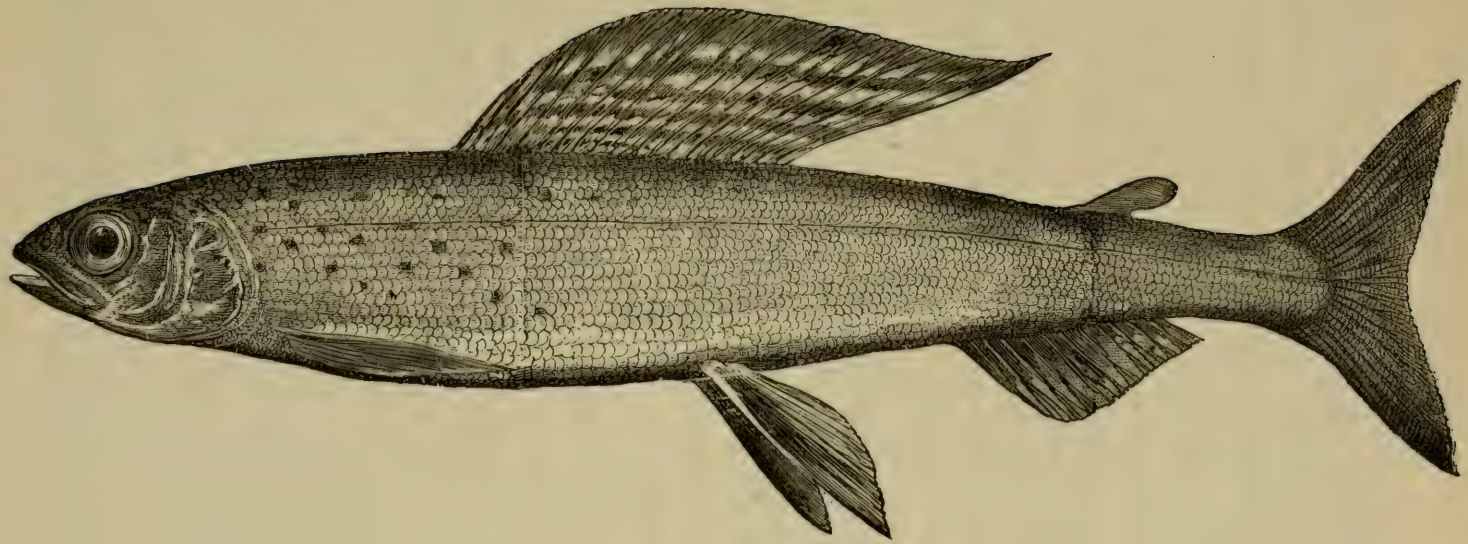
GRAYLING.

Thymallus.—Some time about 1870 Prof. E. D. Cope, of Philadelphia, discovered a few grayling among a lot of fish sent from Michigan, and it made a flutter among anglers, those from England being skeptical about the fish being found in America. He named it *T. tricolor.* I was then breeding trout in Monroe County, N. Y. In

1874 Mr. Daniel H. Fitzhugh, Jr., urged me to go and get their eggs. The fish inhabited streams in the lower peninsula of Michigan which ran east or west, but no others. The books said the fish spawned in March, and so Mr. Fitzhugh and I went on the Sable River on the 28th of that month and caught a number, but they were not ripe. I brought some live fish back to Honeoye Falls, because I could not wait for the spawning season, and left on April 2. Then Seth Green tried it and got to the river on April 30, and found that the fish were through spawning. He dug about 100 eggs out of the gravel and took them to Caledonia, N. Y., where his partner, Mr. A. S. Collins, hatched a few, but did not rear them.

Then there was a rush of anglers to the stream, for I had three columns on grayling fishing in "Forest and Stream" of April 23, 1874, and Norris, Hallock, Milner, Dawson, Bowles and others went for the grayling. The next year Mr. Fitzhugh and I were on the river from April 5 to 15, and struck it right. (See "Forest and Stream," May 13, 1875, from which I take the following): "Of the 118 fish taken four were fully ripe and their eggs flowed freely; six more yielded a portion. A fair proportion of milt was obtained and the eggs were packed in cups and boxes. A few were given to N. W. Clark & Son by Mr. Fitzhugh, and 8,000 were taken to Honeoye Falls. Had it been possible to have stayed a week longer we could have easily got ten times the number; but as my leave of absence (from Prof. Baird) had expired we left Camp Bowles on the 11th and went up the river to spend one day fishing for yearlings."

The eggs hatched in about twelve days after incubation. They were small and light in color, measuring 8 to the inch. The fish were small, with a very small sac.



GRAYLING (*Thymallus ontariensis*).

They swam at five days old and took food the next day. I raised about 600 yearlings, which were 4 to 4½ inches long the next spring. My trout farm was not a success, and in the spring of 1876 the property was rented to a farmer, the large trout were sold and I opened the screens and let all yearlings go into the trout stream below. This stream had 100 chubs to one trout in it, and if any grayling lived to breed in it their progeny stood a poor chance.

The adult fish brought down in 1874 lived but never spawned; they seemed to have been made barren by removal from Michigan within a few days of the spawning season.

Mr. Frank N. Clark made some trials with grayling and so did the Michigan Fish Commission. Under date of Feb. 23, 1899, Mr. Clark writes: "In response to your letter, under date of Feb. 18, in reference to the grayling matter, allow me to say that I can only refer you to my report to Prof. Baird. You will find it in the annual printed report of 1884. I have had specimens of grayling in the ponds here from time to time, and my experience has been that they acclimated themselves to their surroundings in every respect, with the exception of the fact that their eggs never developed properly. In many cases there was ovarian disease, and the ova apparently sloughed away.

The only way to get good eggs is to procure the wild fish just a few days before they are ripe; then hold them in penning crates, and when they are ready to spawn handle them the same as whitefish. They cannot be successfully manipulated if held for any great length of time."

The Au Sable is now a trout stream, but it is said that a few of this beautiful, graceful fish are still there. Of

all the fishes I ever caught it was my favorite. Tender mouthed, it needed delicate handling, and—— But perhaps the memories of camping with "Dan" Fitzhugh and his guide, Lew Jewell, have something to do with this. A small grayling has not the "magnificent dorsal" which caused Richardson, the naturalist of the Franklin expedition, to name the Arctic species *T. signifer*, the standard bearer; but it has a square fin at first. When the fish is 10 inches long the last rays of the fin prolong and are colored to vie with the tail of a peacock.

There is a grayling in Montana which Prof. Milner, Rep. U. S. F. C., 1872-73, named *T. Montanus*. Dr. James A. Henshall, Superintendent United States Fish-culture Station at Bozeman, Mont., has been breeding this Montana fish. In a paper read by him before the American Fisheries Society, 1898, among other things, he said:

"Mr. Sprague took some 3,000,000 grayling eggs, 1,000,000 of which were hatched and planted in Elk Creek; 50,000 eyed eggs were shipped to the Manchester (Ia.) station; 50,000 to the Leadville (Col.) station, and 10,000 to the United States Fish Commission exhibit at the Omaha Exposition, all of which, by extra precautions in packing, arrived at their destination in good condition. About 1,500,000 were shipped to the Bozeman station, but many were lost owing to a lack of ice for packing the eyed eggs. Some green eggs were shipped as an experiment, and though seemingly in good condition on arrival at Bozeman, they all died soon afterward. . . . About 500,000 eggs were hatched at the Bozeman station, and at least 50 per cent. of the fry are alive, and most of them are feeding. . . . In stripping the female grayling the eggs are a little harder to start, but are then extruded more freely than in the

case of the trout. About 3,000 eggs is the average for a fish of 12 inches in length. The eggs are white and as clear as a crystal. They are smaller than the native trout (*S. mykiss*) eggs, but after impregnation and the absorption of water will average 1-7 inch in diameter, while the native trout eggs are 1-6 inch, and the brook trout (*S. fontinalis*) eggs are 1-5 inch in diameter.

"Soon after fertilization the eggs become glutinous and adhesive, forming bunches or masses of various sizes, when fungus rapidly develops and kills the egg. This renders the work of picking laborious, but imperative."

The eggs of the Michigan grayling, now called *T. ontariensis,* had no adhesive quality, and this, to me, is evidence that there is difference enough to warrant the Montana grayling being classed as a different species.

In England trout and grayling have lived in the same streams for centuries, but the trout, it must be remembered, is *S. fario* and not *S. fontinalis.* Grayling also inhabit the same streams in Montana with the Dolly-varden trout, both being indigenous.

The Michigan Commission made persistent attempts to propagate this fish in 1886, 1887 and 1888 with no success, although they kept the fish under as favorable conditions as possible, but got no eggs from them.

So much for fact. Now for a bit of theory. In examining wild grayling I was at once struck by the singular stomach, which was so muscular as to remind one of the gizzard of a fowl or that of the "gillaroo trout" of Ireland. This latter fish is merely a brown trout which has thickened its stomach by feeding on caddis worms with stony cases (see chapter on "Insect Food"), and the grayling has a stomach full of gravel and sand from this cause. It is possible that a few might breed if in

a pond where this food was as plenty as in their native streams. It is worth trying.

CHAPTER XVIII.

THE WHITEFISHES.

Here is a genus of the family *Salmonidæ* called *Coregonus,* of which the well-known toothsome fish of the Great Lakes called "whitefish" is the head of the family. It is *C. clupeiformis,* a name which denotes its shad-like shape. It does not take the hook readily, although such "accidents" have happened. The smaller *coregoni* are known as ciscoes, lake herring, etc. Having hatched but few of these fish from eggs taken by others, I thought best to ask the Hon. Herschel Whitaker, of the Michigan Fish Commission, to give me something on this subject for the book, so that the reader would get it from a better authority.

Mr. Whitaker (Feb. 5, 1898) writes as follows:

MY DEAR MATHER—I inclose herein a chapter on the whitefish spawning as conducted on the Great Lakes, which I hope may be satisfactory. I hope you will find it of some value to you. It is somewhat longer than you suggested, but I found it impossible to keep it within the narrow limits suggested, although it will not overrun it much.

CHAPTER XIX.

THE WHITEFISH AND ITS CULTURE.

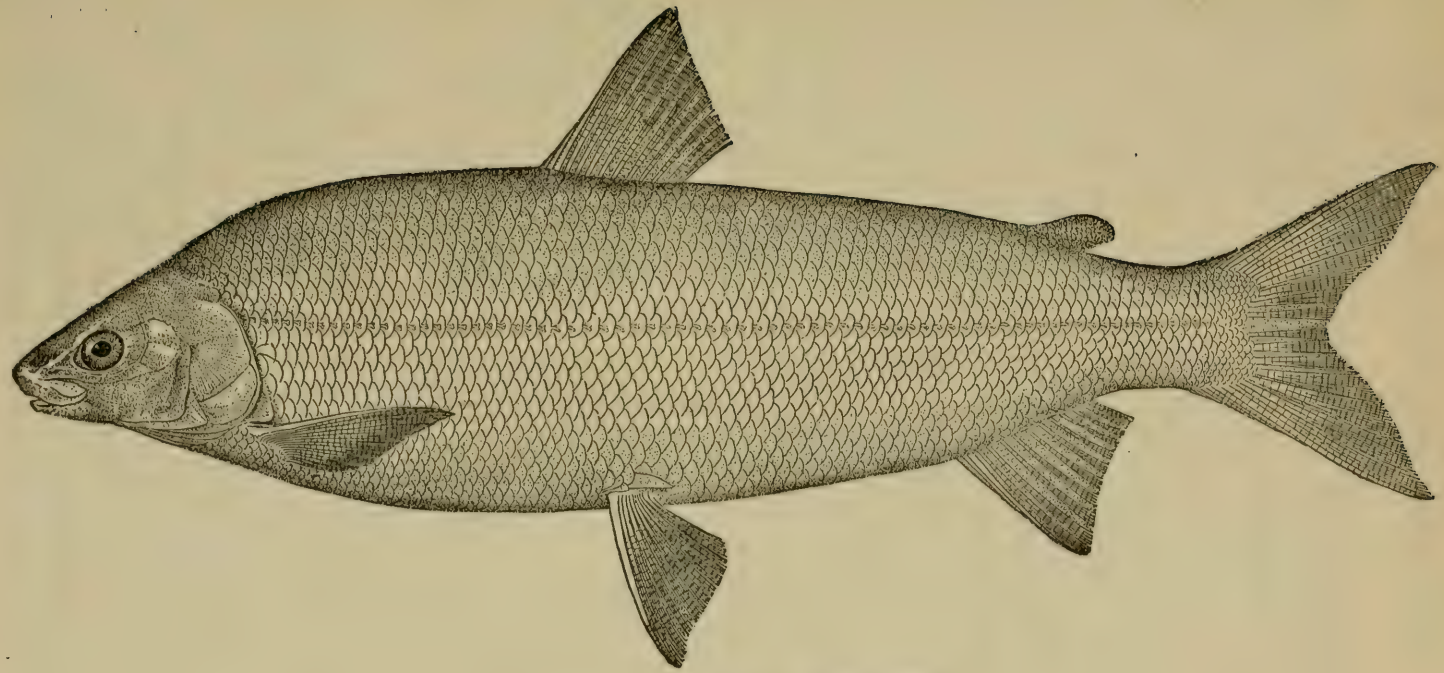
By Herschel Whitaker.

The whitefish is one of the most valuable commercial fishes found in the fresh waters of this country. It is highly esteemed for its fine flavor and always commands a high price in the market. Like the other members of the *Salmonidæ*, it responds kindly to methods of artificial propagation, and its culture is uniformly attended with the best results.

Its spawning season varies somewhat, but the month of November may be said to cover the principal part of its spawning period. Beginning with the month of October the fish gather on the gravelly and stony reefs and shoals of the lakes, both in and off shore, and hover on about these places until the spawning season has closed, when they retire to the deeper waters.

The females are quite prolific, the larger ones casting anywhere from 30,000 to 70,000 eggs in a season, the average in a catch of from 10,000 to 15,000 being from 25,000 to 35,000 to the female.

Two methods are followed in taking the eggs for artificial propagation. The method most generally pursued, because of the natural conditions surrounding the fisheries, is to take the eggs from the fish as they are taken from the gill and pound nets when they are lifted. This method is somewhat uncertain as to result, and usually the eggs taken in this manner give a lower percentage of fertilization than those handled by the



WHITEFISH (*Coregonus clupeiformis*).

method stated later on. If it is possible to take large numbers of parent fish at the precise time when the eggs are fully matured and ready to be cast, with an adequate force of strippers, a good percentage of impregnation may be secured. The season when this fully ripened condition is reached is comparatively short, and the uncertainties surrounding the work are so many that results are always problematical. The fish linger about the spawning grounds for some time, but the period covered by the actual act of spawning is brief. To secure the highest percentage of fertilization the eggs must be thoroughly ripened and the impregnation must take place under the most favorable conditions. Those taken before this ripened time arrives give poor results and a low percentage of impregnation, the percentage depending upon the closeness to the condition above mentioned.

In making this method of collection a crew of strippers and helpers sufficiently large to handle the greatest number of fish in the shortest possible time is put on the fishing tugs or boats, equipped with all the necessary appliances for the work. The boats go out to the fishing grounds and begin lifting the nets. While they are being taken in the gravid females are relieved of their eggs and they are artificially fertilized. The same method is followed in the impregnation of the eggs of the whitefish as in the fertilization of trout eggs. These operations are usually conducted under many difficulties. The locality is the open lake with the rough seas, which are common in the autumn; the temperature is usually about the freezing point. The decks of the boat, more or less covered with ice, are crowded with the fishing crew and the strippers and encumbered with the usual paraphernalia of the boat and the utensils of

the spawn gatherers. Work under such circumstances is of necessity hurriedly done, and as the fish die shortly after being taken, the spawn gatherer must make haste in his work.

There is another method giving surer and better results, although the physical conditions are such on the larger areas of water that it can be carried on in but few places with any degree of success. By this method the fish are impounded when taken and are held alive in confinement until the eggs are ripened, when the fish can be stripped, with excellent results. The requirements for such operations are a locality where fish can be taken in large numbers, and a sheltered location where the pounds in which the fish are held may be protected from the autumn gales and seas. Operations of this character have been carried on for several years on the Detroit River, and are substantially as follows:

Beginning with about the third week in October, the whitefish in the upper end of Lake Erie begin a general movement out of the head of the lake up the river, seeking the spawning beds in that stream and in the lower end of Lake St. Claire. Preparatory to this run the fishing grounds, which are operated with seines, are put in readiness for the coming of the fish. At each fishery a number of crates, about 6x12 feet in size, made of 2½-inch strips an inch thick, are nailed to 4x4 scantling uprights, one at each corner and one in the middle on each side, the floor of the crates being constructed in the same manner. These boards are fastened to the uprights so as to leave spaces between the boards of from one to one and a half inches, to permit a free circulation of water through the crates and still prevent the escape of the fish. Inside each crate is constructed a false bottom that may be raised and lowered at will to any de-

sired height, giving complete control of the fish in the crates and facilitating handling when they are removed for stripping. These crates are placed in the margin of the river near the fishery, in a depth of water at the ordinary stage of from four to ten feet, and firmly anchored in position to stakes. They may be placed in single or double rows, abutting each other end to end. The crates are placed convenient to the apron over which the seine is drawn in fishing. Behind and beneath this apron is excavated a trench about 8 by 10 feet in size, with a depth of water of about two feet, with palings so placed on the riverside as to allow a free passage of water into the trench. The fish are discharged from the net directly into the trench without being handled. From this pound or trench the fish pass through an artificial channel or small canal to the first crate and are subsequently removed to the other crates with scap nets as desired.

From the middle or latter part of October the fish taken pass over the apron as fast as caught and then into the crates, where they are held alive in good condition until fully ripened, when the spawning operations begin. The fishing is continued uninterruptedly from the beginning of the run until the close of the season, hauls being made every hour, day and night, with double crews of fishermen.

Experience has shown that the mingling of the males with the females in the crates is desirable, the contact of the sexes tending to induce freer and earlier spawning than when separated. About November 1st the females show evidences of spawning, and the stripping begins. The stripper takes his position on the platform between the crates, with a pan into which the eggs are to be stripped. He is seated on a low stool, with ordinary

washtubs on each side, in some of which are placed a number of female fish, in others the ripe males; other tubs being used for fish of both sexes not yet ready for spawning, which are culled out by the spawn taker as he proceeds. Two or more assistants, equipped with long-handler scapnets, then begin to take the ripe fish from the crates, and the stripper begins operations. With a large number of fish two or more strippers are working at the same time; the entire time of one assistant is occupied in looking after the eggs when stripped. The eggs of several females and the milt from several males are stripped into the pan until a sufficient number of eggs are taken, when it is set aside, the eggs are washed up, and an attendant adds water from time to time as required and as the space between the enveloping membranes fills with water. The eggs are then allowed to stand until removed to the hatchery, which is done once a day, the eggs being placed in ordinary milk cans containing from twenty to forty quarts, according to the distance they are carried. On arriving at the hatchery the eggs are carefully measured, between three and four quarts of green eggs being put in each jar, where they are kept automatically in motion by the water which passes through the jar until hatched. After the percentage of poor eggs has worked off eggs are added to the jars, each jar finally carrying four quarts.

The hatching period covers from 120 to 170 days, varying according to the temperature of the water and the air during the hatching season. During the first three or four weeks the percentage of unfertilized eggs, being of lighter specific gravity, rise to the top of the jar and are taken off with a rubber tube, about a quarter of an inch inside diameter, used as a siphon. The jars

are freed of the poor eggs in this way better than in any other manner. In drawing off the poor eggs in this way a small number of fertilized eggs are unavoidably taken off with the poor ones, but the mass thus removed is placed in what is known as "hospital jars," where eventually they are separated from the poor ones and saved. With the Chase automatic jar a force of three men will care for 200,000,000 whitefish eggs after the percentage of poor eggs are worked off, until the hatching season comes on, one of the men acting as night watch. The only care required during this period is to see that the circulation of the water is maintained constantly in the jars. The average temperature of the water during the month of November, when the eggs are mainly taken, as shown by carefully kept records, is about 38 degrees, the minimum being 32, and the maximum about 46. The mean temperature of the air during the same time being about 36, with a minimum of 21 and a maximum of about 51.

During the stripping the spawners are sheltered by a rough board house; but this is only used during the severe weather, and is designed rather for the comfort of the men than for protection to the eggs, which rarely, if ever, become chilled by exposure to the air. The eggs are sometimes, on occasional days when the sun is too warm and bright, carried into this shelter for protection from the light and heat.

The hatching time arrives, the shell of the egg has become thin and weak, and on some warm spring day, the young fish having completed his development in the egg, feeling the irksomeness of his confined quarters and the thrill of a warmer temperature, gives his tail a flirt, and with one supreme struggle he bursts the bands of his environment and comes forth a young and

active fish, ready to start out on a new career in a larger field of activity. He begins life well equipped with a stock of provisions stored up in a knapsack which he carries upon his belly. This sac contains a portion of the food on which he lives for the next fortnight or more of his life, but being small as compared with the bulk of his body, it is no impediment to active and vigorous movement. He belongs to what is termed the "buoyant" fishes, swimming freely at all times from his birth, in this respect differing from the trout with its enormous sac, which encumbers its movements so that it lies for days prone upon its side almost helpless. This marked difference between the whitefish and trout makes it possible to hatch whitefish by the hundred millions, while the hatching of trout is limited to a few millions, and at a greatly increased cost. The whitefish can be hatched in automatic jars, because when the young fish hatches he comes to the top of the jar and goes over with the outflow of water, while the trout, weighted down with his heavy sac, falls to the bottom of the jar. The specific gravity of trout eggs is greater than that of the whitefish, and the force of water required to keep them in motion wears the sac of the trout and results in premature hatching.

Observations made on whitefish fry at the Detroit hatchery for two or three years has settled beyond question the fact that the young fish begins to take food, by the mouth, sometimes as early as the third day after hatching, and within four or five days quite freely. Since this fact has been fully established the custom has been to put out the young fish within a few days after hatching. They are shipped in carload lots of three to four millions to the various lake ports reached by rail, where they are put upon tugs and con-

veyed to the natural spawning beds, and there carefully liberated, where natural food is abundant.

The method of impounding whitefish above referred to possesses marked advantages over the other method, because the fish can thus be held alive and in good condition until their eggs have all been taken. They are continuously held under observation, and when fully ripened can be handled with the best results. There have been seasons when the taking of eggs of whitefish directly from the nets on the open lakes has yielded very unsatisfactory results, while for the same reason the impounding method has given most satisfactory results. It has been pursued continuously for years by the Michigan and Canadian Fish Commissions, with such excellent results that it may be said that it is sure to yield uniformly a large quantity of eggs, sometimes more than the capacity of the hatcheries will accommodate.

In distributing the young fish it has been found best to establish at convenient places on the lakes what are called "Relief Stations." These stations are operated for only about two months in the last part of the hatching season, the eggs being removed to these stations at as late a date as possible consistent with safety. For the first part of the season the eggs are all carried at the home station, this method resulting in economy, and the subsequent removal to the relief stations makes the distribution easier, and avoids the overcrowding of young fish at the hatching time, and consequent loss.

As one of this family, the Adirondack frost fish, has adhesive eggs, its treatment will be found in Section V.

SECTION IV.

OTHER FRESH-WATER FISHES WITH FREE EGGS.

We place fish eggs in two classes—the free or non-adhesive eggs and those which are glutinous and either adhere to sticks, stones, or bunch up, and those held in a mass. The free eggs give little trouble, and only one fresh-water fish that I know of lays its eggs in a mass, or string, and these are no trouble at all.

CHAPTER XX.

PIKE, PICKEREL AND MASCALONGE (*Esox*).

While I believe that the country would be better off if all the pike tribe were exterminated, there are those who not only do not agree to this, but actually breed them, therefore they are given place here. They are ravenous fishes—"fresh-water sharks" they have been called—whose food is wholly fish, and they feed all winter. I estimate that a 10-pound pike (*Esox lucius*) has been at least four years growing, and in that time has consumed fish as follows: First year, to grow 1 pound, 40 pounds; second year, at $3\frac{1}{2}$ pounds, 140 pounds;

third year, at 6½ pounds, 260 pounds, and in the fourth year, at 10 pounds, 400 pounds of fish—making nearly half a ton of fish to grow his beastly carcass, worth one dollar in the market. Their digestion has been compared to the action of fire, and 3 pounds of fish per day for a 10-pound pike would be a light luncheon. The States of New York and Wisconsin breed the muscalonge, but why not the pike and the pickerel (*Esox reticulatus*) as well?

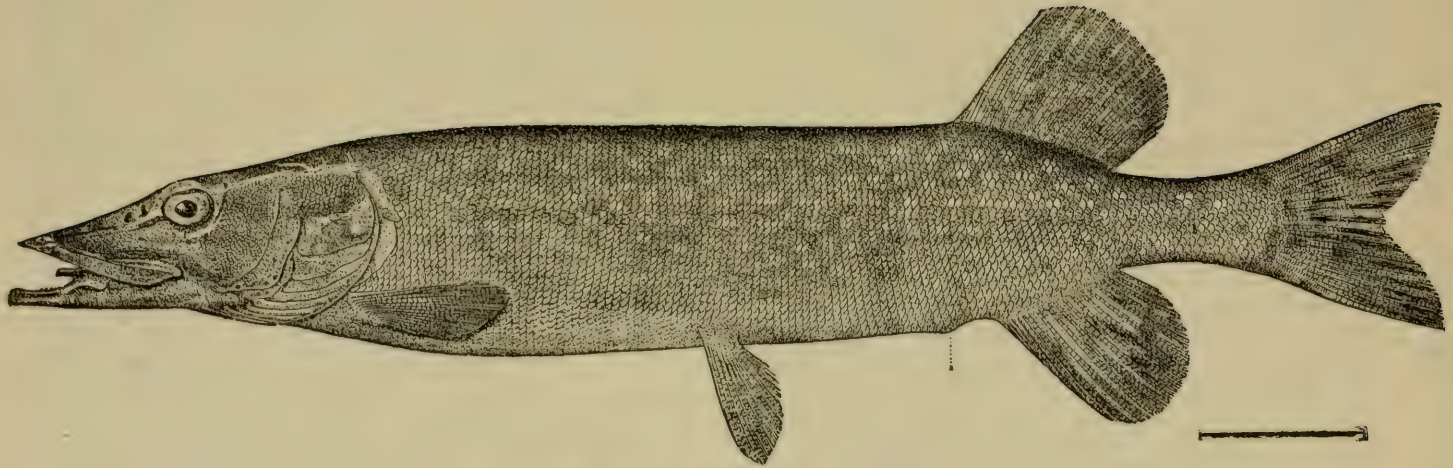
I don't know that pickerel have been bred. In 1875 Mort. Locke and I took some spawning pike, and he suggested that I hatch some. I impregnated about 2,000 eggs, put them in damp moss and took them to my hatchery. They were too light to remain in the troughs, and I made a box like Green's shad box and put them in a stream below. They hatched in seven days, some 500 of them, and I then threw them up on land.

When the State of New York began hatching muscalonge at Chautauqua lake the men had an idea that the eggs must be at the bottom of the lake, and made boxes with double wire top and bottom, to prevent small fish from nibbling any heads or tails that might work through, but now they use hatching jars.

CHAPTER XXI.

SHAD (*Clupea sapidissima*).

This is the finest of the herring family for the table, but the most important, by reason of its numbers, is



GREAT LAKE PIKE (*Esox lucius*).

the sea herring (*Clupea harengus*). Shad are a salt-water fish, and begin to ascend the rivers of Florida in January, those of North Carolina in February. In the Hudson the fishermen expect the first fish about the middle of March, and so on up the coast to its northern range, which Jordan gives as the Miramachi River. It only visits the rivers to spawn, and is in its finest condition when fresh-run from the sea.

When there are heavy snows to the north, which hang on late and then let down a lot of snow water, the shad will remain in the sea off the mouths of the rivers until the temperature suits them, when they will rush up, and the season is short and the catch light. The fact that shad spend the greater portion of their lives in the ocean, coming into the rivers merely to spawn, is generally known, but it has long been a mystery as to just what part of the ocean they located in after leaving the rivers.

Twenty-five or thirty years ago the theory was that the shad went to the tropical regions after leaving fresh water, and that they were returning from those regions when they appeared off the coast of Florida in February and gave off from the migration a certain number of fish for each of the main rivers as they passed north, reaching the Hudson in March. Investigations prosecuted by the United States Fish Commission have shown that the shad don't go far from the mouths of the rivers which they had previously entered for purposes of spawning. The investigators of the commission have caught shad, in a net specially constructed for the purpose, at points in the ocean some 200 miles or so from the mouths of rivers. These fish are ever on the hunt for a temperature of about 60 degrees, and they go farther to find a depth where that degree pre-

vails. This causes the spawning season to vary, because the shad will not enter the rivers while there is much snow water in them.

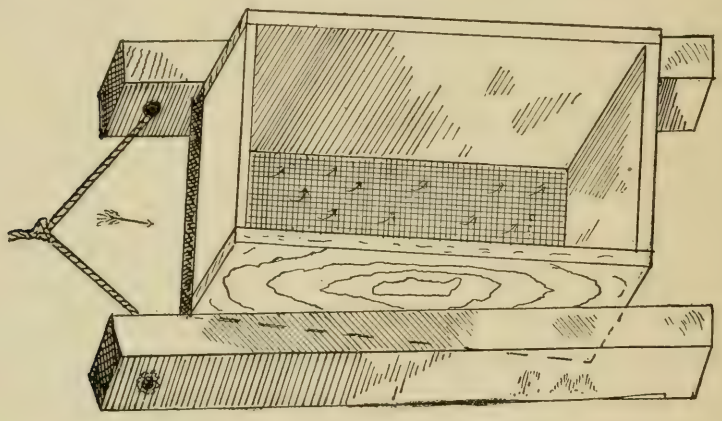
Because shad eggs hatch in four or five days the hatching is done at, or near, the fisheries. Shad spawn at night, usually before midnight. They seek eddies where their very light eggs may be kept from sinking by slight currents. They spawn at the surface of the water, a pair coming up and placing themselves on their sides, making a great fluttering as they discharge eggs and milt at the same time. The eggs are not adhesive.

At South Hadley Falls, on the Connecticut, we remained on shore, and had the fishermen bring us the fish, because the water was deep and the fish close at hand. On the Hudson the spawn taker, in a suit of oilskins, sat in a boat at the bag of the net, and after wetting a pan to free it from dust, would put the head of the fish under his left arm, holding its tail in the left hand, and strip toward the vent with his right, taking great care to leave plenty of space between the sharp saw-belly and his hand. Even with the care which experience teaches, I have had the skin between thumb and forefinger cut many times.

The pans would be taken on shore, where an expert would leave them in the milt and water, occasionally adding a little water and moving his hand gently through the mass until he announced that they had "come up," *i. e.* had absorbed all the water, and consequently milt, that they would take, and were ready to be put in the hatchers. This he determined by feeling—the eggs at first being flabby and not to be felt, but when full feel hard as they lightly strike the hand.

In the early day we used Green's floating box. This was a box with no cover and a bottom of fine wire-cloth

(about No. 14), all well coal-tarred. Pieces of scantling were nailed to the sides of the box as floats, but put at such an angle that a box two feet long had one end four inches out of water and the other seven inches. When fast at one end the bottom presented an incline to the current which kept the eggs gently moving, and the box, or gang of boxes, would swing with the tide. There was tide-water where we hatched, ten miles below Albany, N. Y., but always fresh. The tide was



GREEN'S FLOATING BOX.

feeble, and had long periods of slack at high and low, when the men would have to gently shake the boxes to give circulation of water.

Green's box was good in its day, and in lieu of better apparatus may be used now. The McDonald jar is used by all the State and Government shad stations now, even though they pump the water for the purpose. With Green's box we could not remove dead eggs until after they had "fungused up," and this is how we did it: A light wire frame, three inches square, covered with millinet, or mosquito netting—the former for choice—would be put on a handle and worked through

the eggs, those with fungus adhering to the net, which was washed overboard and tried again. This kept a man at it all the time, and the fungus did the same; the cleaning was imperfect, but was the best we could devise. In the jars the dead eggs collect on top of the moving mass, the outlet tube is lowered on them, and out they go before a bit of fungus has formed, and one man can do the work of ten as we first did it.

Shad eggs are very delicate and will not bear much handling. They are sometimes floated on flannel trays to take to a station, but they must be handled more carefully than trout eggs need be.

The young shad swims from the time it leaves the shell, and is kept two or three days before turning out, until its sac is absorbed and it can take food. When liberated it strikes for the middle of the river, contrary to the habit of most young fishes, and escapes destruction there by its inconspicuousness. It is a mere shred of albumen. I have had men look into a 10-gallon can, where there were 30,000 shad fry, and declare that they could see nothing. After pointing out the little squirming things the usual question was: "Do you think they will ever amount to anything?" As if every shad was not once a mere "shred of albumen."

If it had not been for the artificial propagation of shad the supply would have long since been exhausted. The increase of railroad facilities has widened the area of consumption. Fifty years ago the distribution of shad scarcely reached Buffalo; now it includes a city as far West as Omaha. The rivers are more prolific of shad than ever, if we except the Connecticut, where their propagation was suspended for a number of years, and it is all due to the fishculturist.

There were no shad on our Pacific coast; they were

planted there by the United States Fish Commission, year after year, and now they are not only plenty where they were planted, in the Sacramento River, but have strayed up the coast and stocked rivers of their own volition, as far up as Puget Sound. Not only that, but shad have increased in size. Mr. Blackford reports seeing shad in San Francisco markets which weighed 16 pounds. A few years ago a 6-pound shad in New York markets was considered large, and an 8-pounder a "monster." I have seen several Hudson River shad weighing 10 pounds during the past few years, and this was not an uncommon weight a century ago.

SHAD FRY ACROSS THE ATLANTIC.

Germany wanted shad fry, and as adult shad cannot be handled without killing them, Prof. Baird detailed me to take them over, with Mr. Aaron Anderson as an assistant. We took 100,000 newly hatched fry from Holyoke, Mass., on August 4, 1874, and sailed on the North German Lloyd steamer Donau the next day. We had ten cans and 10,000 gallons of Croton water in the steamer's cemented water tanks below. We stood six-hour watches and worked hard, through all the horrors of sea-sickness, but we didn't let a little thing like that interfere with duty. The illness only lasted three days, and the fry were doing well. We then siphoned out the dead, which were 200, not more than would have died in the river. Every three hours each can was one-third emptied and refilled with fresh water. On the 9th the fish had absorbed their sacs, and, by their lively dartings, were looking for food, and as what they fed upon must necessarily be small we washed pieces of fresh

beef, fish and liver in the water, but to no purpose. My diary of losses shows the following: August 5th, 9; 6th, 200; 7th, 1,000; 8th, 20; 9th, 100; 10th, 3,000; 11th, 500; 12th, 1,200; 13th, 5,000; 14th, the whole lot of about 90,000. We had hopes of pulling them through until the 12th, when they were eight days old, and we could see they were weakening. We were at Southampton when the last fish died, but went on to Berlin and reported. If we could have planted them in the Weser on the 12th it would have looked like a success, but I think the fry were then too weak to take food.

THE BELL AND MATHER HATCHING CONE.

At the beginning of the shad season on the Delaware in 1875 Prof. Baird asked me if, in my opinion, shad fry could be taken to Germany. My answer was: "Yes; if we can hatch them *en route,* and delay the hatching from four to eight days, and so get the fry there before they are enfeebled by starvation; but we don't know how long shad eggs may be retarded, as no one has experimented in that direction, and as they spawn on a rising temperature, it is evident that we cannot ice them as heavily as we can the eggs of *Salmonidæ.*"

The professor gave the matter a moment's thought, and asked: "Would you like to experiment on this line and try it again, if you believe you can retard the hatching and get the fry safely over?"

Then it was settled that I should try it in my own way, and I began in the basement of the Smithsonian Institution with the arrangement here figured.

Fig. 1 is the experimental "hatcher." A is the reservoir furnished with a cock B, by which the flow

through the rubber pipe C is regulated. E is the "hatcher" with a wire cloth bottom at F. The water enters at D and strikes a distributer, Fig. 2 H, passes up through the wire on which the eggs lay, and out

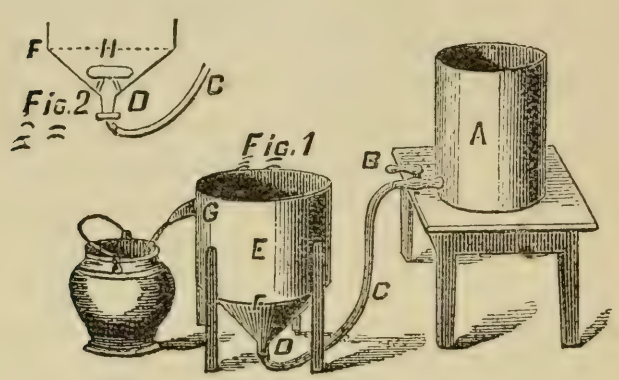
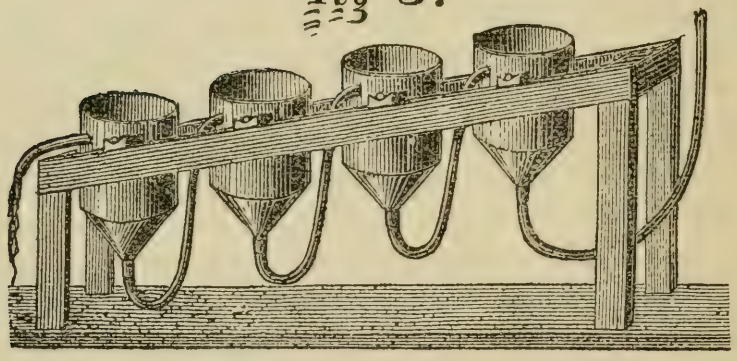


Fig 3.



through the spout G, which is provided with a strainer. Fig 3 is the arrangement of a gang of hatchers, each one hung so as to swing on a frame; the frame also can be hung instead of standing upon legs if thought advisable. By means of No. 1 a valuable series of experiments can be made with water at different temperatures, and so it can be accurately de-

termined in what time the eggs will hatch, and how low a figure they will stand. The passage to Germany may take twelve days, and two more should be allowed for travel there, making fourteen in all. The eggs usually hatch in rivers in three or four days at a temperature of 70° to 80°. We used no ice on the passage, and the water averaged about 62°.

The idea in Fig. 1 was to have a man on duty night and day to pour the water back into reservoir A a few times and then renew the water, just as would be necessary at sea. The eggs did not hatch, and Prof. Milner, who had charge of all the shad work, came to see me. I complained of bad air and the proximity to a rancid old whale skin, and when he said I had *carte blanche* to go where I pleased and no restrictions of any kind would be placed upon me, I girded my loins, took Charles F. Bell, a young medical student, and went to Point Pleasant, Pa., up the Delaware River, where I put up my "laboratory" on the upper piazza of a hotel which opened from our bedrooms.

Much time was lost in experimenting; it was found that a temperature below 55° Fahr. was fatal to the eggs; that the broad screen, placed as in Fig. 1, did not give motion to the eggs, and that motion was as necessary as circulation. The embryo developed to a certain point, but had no pigment in its eyes. Then we had a hatcher made like Fig. 4, with a small screen at the bottom of the cone. Eureka! It gave motion, and now the lowest temperature was all we needed to know. Prof. Milner telegraphed from Holyoke, Mass.: "Monroe A. Green and Welcher have apparatus to hatch at sea; if you are not ready, will send them." Bell advised that I answer "ready," as the

temptation to go to Europe on a free trip was strong within the boy; but I was not satisfied about temperatures and did not wish another failure. My answer was: "Not ready; let them go." I do not remember the details of their apparatus, but do know that their eggs were all dead before the ship got outside of Sandy Hook. The Rochester "Express" of August 24, 1875, gives Mr. Green's opinion that jarring in

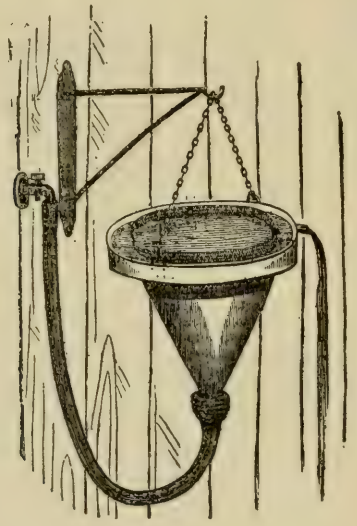


FIG. 4.

Original Bell and Mather Cone.

transit from Holyoke to New York killed the eggs; but, if so, he should have seen this before starting, for he knew a dead shad egg when he saw it. The "Express" says: "The eggs were packed in ice," and that tells the story, to me.

After we had worked out our problem, Bell and I went to Holyoke and put up our hatcher in the kitchen of the hotel, and Prof. Milner said: "You've found

it! Here is a way to hatch fish eggs in bulk and keep them free from fungus; get a patent on it."

I do not look favorably on patent rights, and especially in fishculture, where we all use each other's

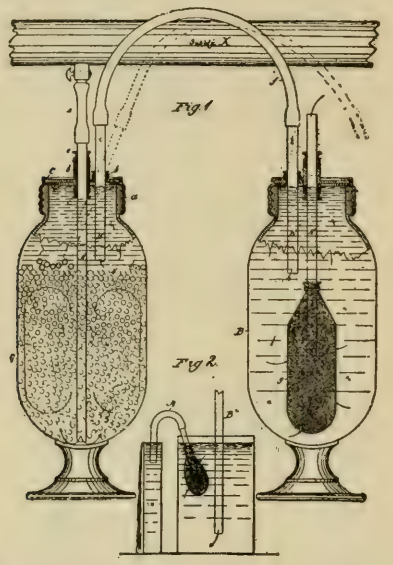
THE CHASE JAR.

brains with more or less credit; some never give any. From this sprang the "Chase" jar, which was patented, and also the McDonald jar.

THE CHASE JAR is round-bottomed, with an open top, which is surmounted by a metal rim having a lip for an overflow. The water is conveyed to the bottom of the jar by a heavy glass tube having a foot

with points on it to allow the water to flow between them.

The McDonald Jar has a flat metal top screwed down tight on a rubber ring; through the top are holes



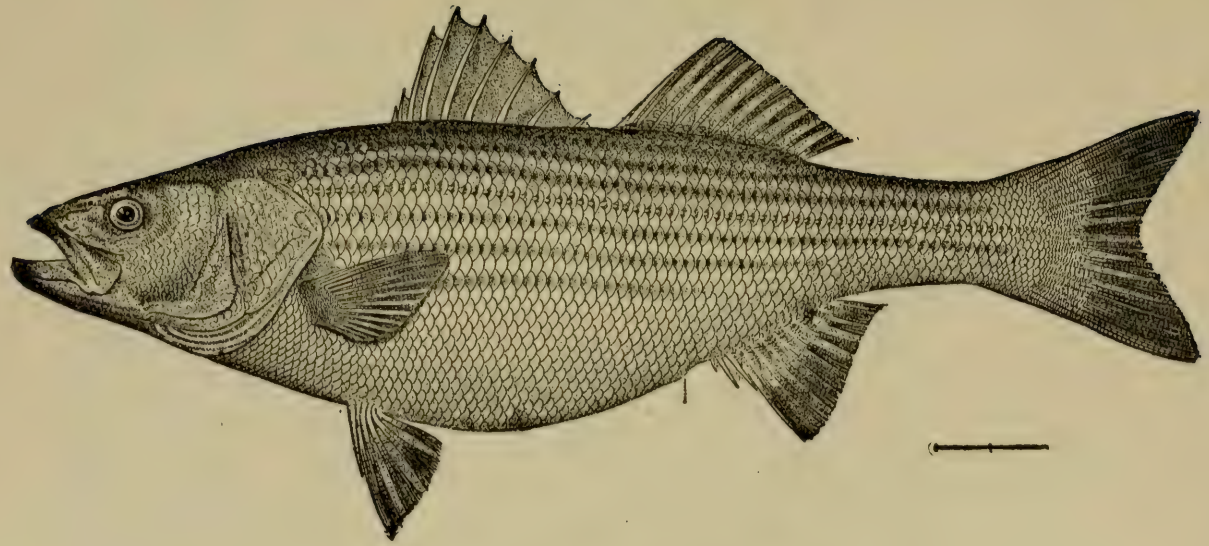
McDonald Jar in Action.—Fig 1. Jar filled with eggs emptying into jar for fry, with strainer on outlet pipe. Fig. 2. Aquarium jar with strainer on outlet emptying into a shorter jar to prevent siphon from sucking dry.

for two glass tubes, inlet and outlet, and these holes have recesses to hold small rubber rings on which hollow screws make the holes water-tight. Each of these jars has its admirers.

CHAPTER XXII.

STRIPED BASS OR ROCKFISH (*Roccus lineatus*).

As the striped bass is for some unknown reason called "Rock" and "Rockfish" south of New Jersey, I



STRIPED BASS, OR ROCK (*Roccus lineatus*).

give both names. It is a splendid fish for angler or epicure, and comes to the New York market weighing from half a pound to sixty pounds and over. The small ones are called "pan bass," and sell for more per pound than the larger fish, which go to restaurants for boiling. All the large ones are females and come to market filled with spawn in May and June. The big fish winter under the ice in the Hudson about Sing Sing, and are caught there in great numbers. Where they spawn in great numbers is not known. If there is any grander fish, so easily hatched and so neglected by the fishculturist, I don't know what it is.

Several men, as well as myself, have hatched this fish by accidentally catching them when hatching shad and were fortunate enough to get a pair. I did this at Castleton, on the Hudson, and at Fish Haul, on the Pamunky River, Virginia; but it was accident that brought them. They spawn in fresh water, but no man seems to know where to get them in quantity.

Some years ago Mr. S. G. Worth, of the United States Fish Commission, reported that spawning striped bass could be found in numbers in the Neuse River, North Carolina, and I think he hatched some there. They may be handled and treated as we treat shad eggs.

This closes the list of strictly fresh-water fishes which we propagate that have free or non-adhesive eggs. All the near relatives of the striped bass, such as white bass, *R. chrysops;* yellow bass, *Morone interrupta,* and white perch, *M. Americana,* have adhesive eggs.

SECTION V.

ADHESIVE EGGS.

With eggs which are free the fishculturist has plain sailing, but his trouble begins when he tackles the adhesive ones, for after all his care in separating them he never knows when he may not find them "all balled up" and the inner ones dying. Ten years ago it was thought to be good work to hatch 30 per cent. of adhesive eggs, but they do better now.

There seem to be two classes of adhesive eggs, as I have observed them under the microscope. To my astonishment, I read Mr. J. J. Stranahan's article on the use of the microscope in the Report of the American Fisheries Society for 1898. I have not room to quote it, nor the discussion following it. Mr. Stranahan advocated the use of the instrument, and the fact was developed that few hatcheries, State or Government, possessed this necessary instrument of the fishculturist. How a fishculturist gets along without one of low power—high powers are of no use to him—I don't know. At Cold Spring Harbor every one of my men could adjust and use a low-pressure microscope. The instrument was my private property, and I don't know if there is one there now or not.

This may seem to be a digression, but it is not.

Only by the microscope could one see that the egg of a smelt was adhesive, but not glutinous. As I understand it, a glutinous egg has some sticky envelope which attaches anywhere it strikes. The egg of a smelt throws out a sort of "foot stalk," which acts like a sucker in attaching it to objects; hence the distinction between "glutinous" and "adhesive," at least in my vocabulary.

The old plan was to work the eggs by hand, through sieves, and by more or less violent means rub off the mucous coating. Messrs. Nevin, Clark, Page and others hit on the use of earth or clay about the same time, and Prof. Reighard, of the Michigan Commission, found cornstarch to be excellent for this purpose. I had no occasion to try these things, for the only adhesive eggs which came my way were those of the smelt, which has a foot stalk like a wineglass, but seems to be capable of throwing this out from any side, and to do it again after one is broken off.

CHAPTER XXIII.

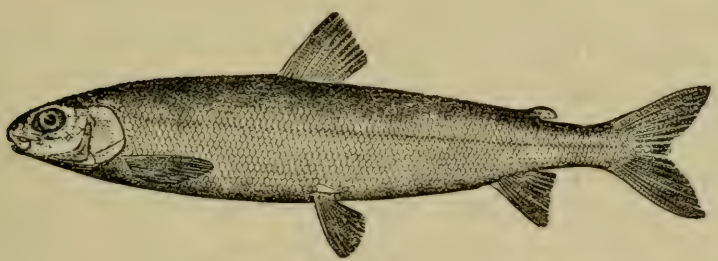
THE ADIRONDACK FROSTFISH.

This small whitefish, *Coregonus quadrilateralis,* is a round-bodied fish, as its specific name implies; also called "round fish," "shad waiter" and "Menomonee whitefish;" comes out of the deep waters to spawn in the streams in the fall and is caught in great numbers and salted for winter use. It ranges from northern

New York and New Hampshire to Lake Superior and Alaska. It is hatched in great numbers by the State of New York.

There are other members of the whitefish tribe, and all are worth cultivating. Never having hatched this fish, I made inquiry of Mr. John G. Roberts, formerly in charge of the Adirondack station of the New York Fish Commission. Under date of March 26, 1899, Mr. Roberts writes as follows:

"The frostfish eggs are quite adhesive and very heavy. I had some whitefish eggs, and being crowded for room for my frostfish eggs last fall, I took a jar



ADIRONDACK FROSTFISH.

partly full of whitefish eggs and filled it with eggs of the frostfish. The latter settled at the bottom at once and did not mix, showing them to be very heavy."

It seems singular that species as closely related in structure and habits should differ so much in the character of their eggs. We find the same thing in the genus *Morone*, the striped bass and the white perch.

On Long Island the tomcod is sometimes called "frostfish," and in other places the smelt is so designated, but this is a fish which has no other popular name than frostfish, and therefore should be left to enjoy it; is one of the "whitefishes," sometimes called

the "round whitefish," because it is not deeper than broad, but as it has a square body Richardson called it *Coregonus quadrilaterale,* and other fellows have changed the generic name. The fish is well worthy of cultivation for food in the Adirondacks and is propagated there. The following is from my monograph on "Adirondack Fishes," 1882: "This fish is one of several species generally called 'whitefish,' the type of which is the large fish of that name found in the Great Lakes. I took them in Big Moose, the Fulton chain and Clear Pond (near Meacham Lake). They are a handsome fish and most excellent for the table. They do not take the hook, and are usually captured in the fall while running up the brooks to spawn, when they are taken in great numbers by traps made of stakes, and are salted for winter use by those living in the woods. They are classed in the same family with the salmon and the trouts, although they have no teeth and have large, loose scales. The presence of the small adipose second dorsal fin and other common characters seem sufficient to place the genera *Coregonus, Argyrosomus* and *Prosopium,* the whitefishes and so-called lake herrings; *Osmerus,* the smelts, and *Thymallus,* the graylings, in the family *Salmonidæ.*"

CHAPTER XXIV.

SMELT (*Osmerus mordax*).

Here is a fish worthy the attention of every State Fish Commission which has lakes fed by streams.

Once the smelt was placed in the family *Salmonidæ* because it had the small adipose second dorsal fin. It has been removed from that family, but keeps on just the same in being one of the most delicate things that can be fried for breakfast. It grows to a foot in length in Maine; but one of five inches suits me best, as I can eat it head, fins, tail, bones and all, and it is better than the big ones. Jordan gives its range as "Nova Scotia to Virginia, sometimes land-locked." They live in the fresh waters of Lake Champlain, where they are called "ice-fish," as they take them through the ice in February and March. They are also found in other lakes.

The New York State hatchery at Cold Spring Harbor is immediately below a mill-dam, although it gets no water from the mill pond. From the overflow to salt water is a shallow stream about 20 feet wide and some 500 feet long. The stream had no fish in it except the mummychogs and an occasional trout that escaped from the hatchery ponds. I resolved to try smelts, and for three years sent men down to a river on the south side of Long Island—we were on the north, on the Sound—and bought several hundred smelts in the spawning season, took their eggs and stocked this nameless stream. After the third year we got enough spawning fish without buying them and stocked waters on Staten Island and in other places. We turned out many millions each year. Mr. George Ricardo, at Hackensack, N. J., had begun smelt hatching before I did, and had met with success by spawning the fish on grass-lined perforated boxes placed in the river, letting the young go free.

Smelt eggs are adhesive, as has been said, but are not glutinous. In nature it spawns in swift water, at

night, and the eggs adhere to stones or any other thing. On a stream where thousands of smelt have spawned at night not a fish can be seen by day; they have dropped back into deeper water. My first plant of some 30,000 smelt fry in 1885, in the stream named, resulted in the getting of over 30,000,000 of eggs ten years later.

A smelt weighing 2 ounces will yield 40,000 eggs; the eggs run about 20 to the inch, or about 500,000 to the quart. At first we took the spawn by hand and broke up the bunching by passing them through a sieve several times to break the "foot stalk;" but after getting better results from some which had been neglected in a hatching trough, we merely placed the fish in the troughs, covered them from the light and got a better impregnation.

A curious thing in this work is that the fish laid their eggs in the stream in less than six inches of water, in direct sunlight, and the great increase shows that they must have hatched in great numbers. In our hatchery we had to cover the jars from even diffused light or they would die.

Perhaps nature provides for this in the bunching habit. During the first years of experimenting with smelts I sent out a lot to the Adirondacks in bunches. My instructions were: "No matter how decayed or fungused they are on the outside, nor how badly they smell, don't throw them away. Open the bunches and you will find them bright and alive inside." The eggs went up in the Bisby Lake region, but I could never get a reply from the man there; but it seemed to me at that time as if nature protected the inner eggs from light and too much oxygen by allowing them to ball up in that way; but then how did the little fish in the mid-

dle get out? Here is a problem. In nature the smelt lays its eggs where the March sun shines on them and they hatch. In the hatchery a mild, diffused light through green window-shades will kill them. I give it up.

SMELT IN NEW HAMPSHIRE.

Under date of December 11, 1879, Mr. Samuel Webber writes from Manchester, N. H., as follows: "The fresh-water smelt has been planted and acclimated in our inland lakes during the last ten years, and is now very plenty in Winnepesaukie, Squam and Sunapee, besides getting a foothold in Massabesie and Northwood, where we have placed them."

There is but one smelt, and it lives in both salt and fresh water, but spawns in streams.

In "Forest and Stream" of April 7, 1881, a correspondent, misled by the name of "frostfish," wrote that the smelt was found in many Adirondack lakes. So much for popular names.

CHAPTER XXV.

THE BLACK BASSES.

The two species are named from the comparative size of their mouths, and are not at all difficult to distinguish if carefully looked at until the characters are fixed in the mind. Then a glance suffices. I will

not go into all the points of difference, but by mentioning the salient points in connection with the cuts one should be able to pick them out.

SMALL MOUTH (*Micropeterus dolomieu*).

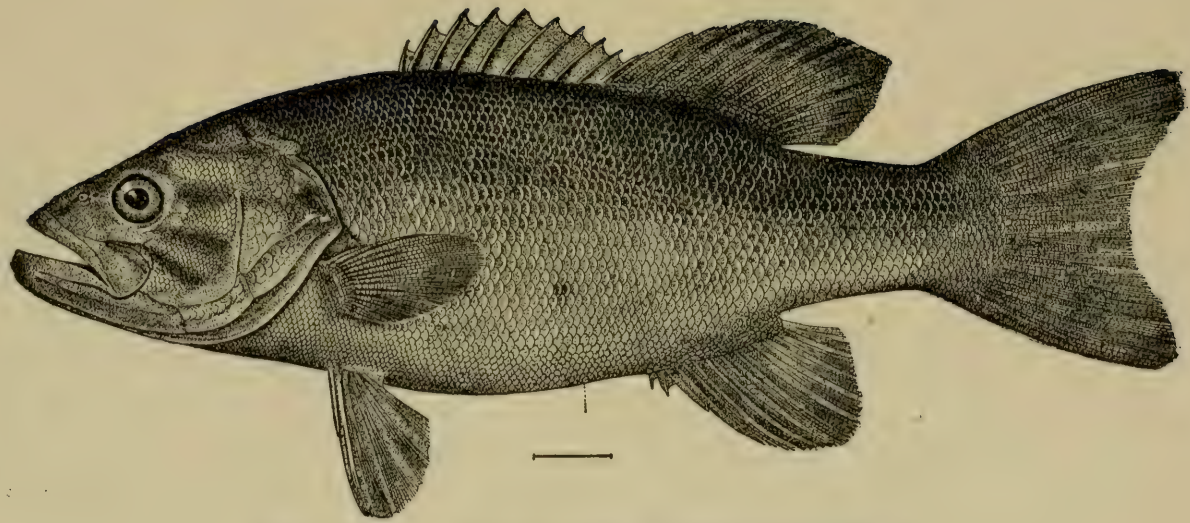
Bone of upper jaw does not extend beyond the eye —the mouth is measured when shut—color nearly a uniform dark green, three bronze bars across cheeks, scales at base of soft dorsal and anal fins; smaller scales; eye usually red.

BIG MOUTH (*M. salmoides*).

Upper jaw extends beyond eye, color dark green with a distinct median band, below which the color is lighter; cheek bars not so distinct, no scales on fins, scales larger. It is called another name in some parts of New York and New Jersey, but as it is time that was dropped I will not mention it.

Often these fishes are found in the same waters, especially in large lakes. The big mouth is best suited for small, shallow lakes with mud and weeds, but I usually advise to put in some of each and the fittest will survive. In 1884 I put into a lake at Cold Spring Harbor, New York, a bit of water of perhaps 30 to 40 acres, spring fed, and from 2 to 15 feet deep, 30 small mouth and 4 big mouth bass. The latter thrived, but I never saw a small mouth taken from the lake. The fish had come a long distance and some had fungus on them when planted.

THEIR CULTURE consists in planting them and pro-



SMALL-MOUTHED BLACK BASS (*Micropterus dolmieu*).

tecting the water for a few years. They sweep nests in the gravel, lay their glutinous eggs in them and watch the nests, fighting off all intruders and fanning the eggs with their tails for circulation. The eggs hatch in four to six days, according to temperature, and remain a day or two on the nest, plainly visible as a dark mass. Then, when the sac is about to be absorbed, they rise, and the old fish remains under them until they disperse to seek food.

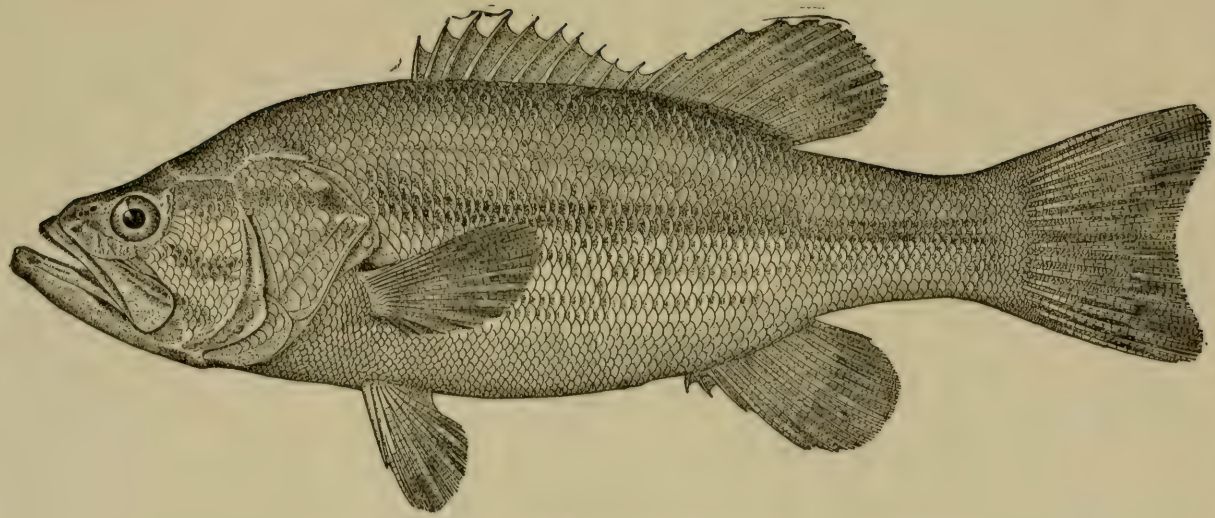
We cannot take their eggs and hatch them, and as the parents do so well at it there is little need to try it. If young are needed for stocking, the nests should be watched and the young taken in dip nets which are lined with millinet or cheese-cloth.

The small mouth is the best fish for streams. In muddy, weedy ponds the flesh of the bass, and all other fishes, is muddy in flavor, and in warm weather much so. The two are about equal as game fishes, notwithstanding a popular notion to the contrary.

Lieut.-Col. Isaac Arnold, Jr., U. S. A., made experiments in hatching black bass from 1879 to 1881. He was then a major and was stationed at the armory at Indianapolis, Ind. He let the fish spawn naturally and removed the old fish when the young were hatched. In the Bulletin of the United States Fish Commission for 1882, Col. Arnold says:

"The male presses the ova from the female by a series of bites or pressure along her belly with his mouth, the female lying on her side during the operation. The male ejects the milt upon or over the roe from time to time, and the spawning process lasts for two or three days."

A few years ago, at a meeting of the American Fisheries Society, the Hon. Herschel Whitaker read



BIG-MOUTHED BLACK BASS (*Micropterus Salmoides*).

a paper on "The Artificial Propagation of the Small Mouth Black Bass," in which he said: "An experimental station was placed on the Thorn Apple River in Michigan. Here two ponds were constructed and 150 adult fish placed in them. Last week the female fish showed disposition to spawn. At the same time they took a large female from the river, stripped her and impregnated the eggs. These were placed first in jars and then transferred to trays. On the fourth day they began to hatch, and on the following day all were completed, and a few days ago there were several hundred fine, healthy fish. When they were first hatched they were almost invisible."

Mr. Whitaker does not say that the male was ripped open to obtain the milt, but, as far as I am informed, this has been found necessary in all such experiments, and the impossibility of getting milt from the male by stripping has been one of the obstacles in the handling of the eggs.

Knowing that Mr. W. F. Page had experimented with black bass recently when in charge of a hatchery in Missouri, I wrote him and obtained the following:

Black Bass Culture.

By W. F. Page.

Strictly speaking, the artificial propagation of the black bass is, up to this time, an unsolved problem; and, in my opinion, will forever remain such. In other places my reasons for this opinion have been given in full. Moreover, in the matter of the handling and care of the alevins (produced naturally) and the feeding of the very young fry, only the least fraction

of knowledge has been gained. It may be accepted that up to the time the young black bass is able to forage on his own account fishculture is a baffled art and of no account in the multiplication of this species. Up to that time dependence must be placed in natural spawning and hatching.

Black bass which have lost the shyness and fright incident to capture and transportation become domesticated, readily spawn, and rear their young in artificial ponds; and only by this method can the fishculturist expect to secure any considerable number of young bass. They may be allowed to spawn in the stock pond, from one-quarter of an acre or larger in size, or an annex spawning pond may be used. Dr. Henshall has given the best description of a bass nest: "Slightly concaved, with a diameter twice the length of the fish." Gravel is undoubtedly excellent material for spawning nests, though by no means a necessity, for I have frequently seen bass spawn on earth. I am informed that the artificial bass nests devised some three years ago have not proved an unqualified success.

The spawning season varies for almost every State, and frequently in the same State. Moreover, the season is rarely the same in any one locality. My observations lead me to think that the bass will not be found nesting before the ground becomes warm enough for gardening purposes, though occasional instances of spawning on much lower temperature have been noted. The period of incubation averages about nine days, and the alevin stage occupies about six days more. Shortly after the food sac is completely absorbed the school, heretofore guarded by the parent fish, disperses in search of natural food—*daphnia, cy-*

clops, etc. If the pond has been so constructed that a good portion of it is shallow water—from six inches deep to feather-edge—and is old enough to have produced a fair crop of aquatic vegetation, the young will find abundance of natural food. When about an inch long they will be found foraging on *gammarus* and *coriza,* and later on larger crustaceans, particularly crayfish and smaller fishes.

When a majority of the crop measures one and a half to two inches long it is advisable to remove them from the spawning pond. This period occurs before the breeders have, usually, finished spawning. To remove the early hatch without disturbing the late spawners, construct the pond to have a long, narrow neck, not over four feet wide, and running to a point where the inflow enters; ten or fifteen feet from the inflow separate the neck from the pond proper by a wire screen of one-quarter to three-eighth inch mesh. The young bass readily find their way through the screen, and show no inclination to leave as long as food is present. The screened-off neck should be closely watched, not only for the numerous enemies of the young bass, but for any sign of cannibalism. To net the young bass from the neck is such an easy matter as not to require explanation.

If it is necessary to keep the young bass for even a day before shipping, it is of the utmost importance that they be carefully sorted, and the different sizes placed in different receptacles. If the fry are to be kept for several weeks, or even days, they must be fed, or cannibalism will surely reduce the number. Any kind of fish, chopped or ground fine, makes a most acceptable food, and it is doubtful if bass fry will thrive on any food except such as has grown in water;

though adult bass have been kept on beef and beef livers. Bass fry take kindly to a fish diet, and thrive and grow on it with little labor and time.

It is doubtful if the practice of distributing very young bass from nests—alevins—will prove successful. They are exceedingly tender and peculiarly susceptible to changes of temperature.

CHAPTER XXVI.

THE CRAPPIES.

Like the black basses, there are two species of this genus, and they are difficult for the novice to distinguish. They are good fishes for warm ponds and streams. In an article on "The Two Crappies," in "Forest and Stream" of June 25, 1898, I took the stand that, as they are as nearly alike as the black basses are, they should be so classed. Heretofore but one species had been called crappie, but as each had a string of local names, many of them absurd, I ventured to hope that in time my simplified nomenclature will be accepted.

SMALL MOUTH CRAPPIE (*Pomoxys sparoides*).

This pretty fish ranges from the lakes and ponds of the Great Lake region, western New York, New Jersey, the streams of the Carolinas and Georgia east of

the mountains, the Mississippi valley, especially northward, it being the most northerly fish of the two. It prefers clear, quiet waters where the bottom is covered with grass, and it shuns muddy waters. The species cannot be separated by color. Both are "undershot," as they speak of the protruding lower jaw of the bulldog and pug, but the small mouth is the least so. (See cuts.) It has seven or eight spines in its dorsal fin, while the other has but six.

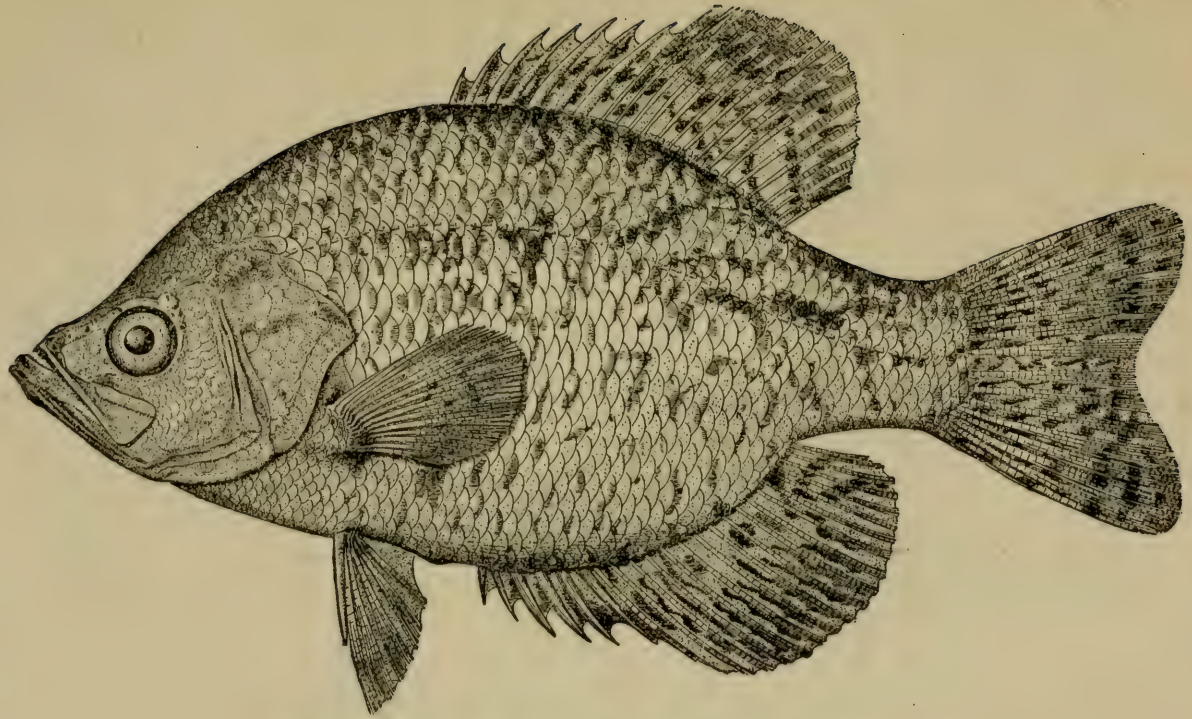
BIG MOUTH CRAPPIE (*Pomoxys annularis*).

This is the more southern species. To one accustomed to both, the elongated thickened lower jaw would proclaim the big mouth at once without counting dorsal spines. These fishes are more alike than the black basses, yet they are as distinct in structure and habits. The big mouth loves muddy bottoms, but is often found with its brother. Note the general shape of the fishes and the smoother outline of the small mouth.

Both these fish are more compressed than the black basses, quite as much so as the sunfish. They are good pan-fish, growing to a foot in length and of some two pounds weight.

CULTURE.

What has been said in this regard of the black bass may be said for the crappies. They have always been favorites of mine and are worth pond room with the black bass.



SMALL-MOUTHED CRAPPIE (*Pomoxys sparoides*).

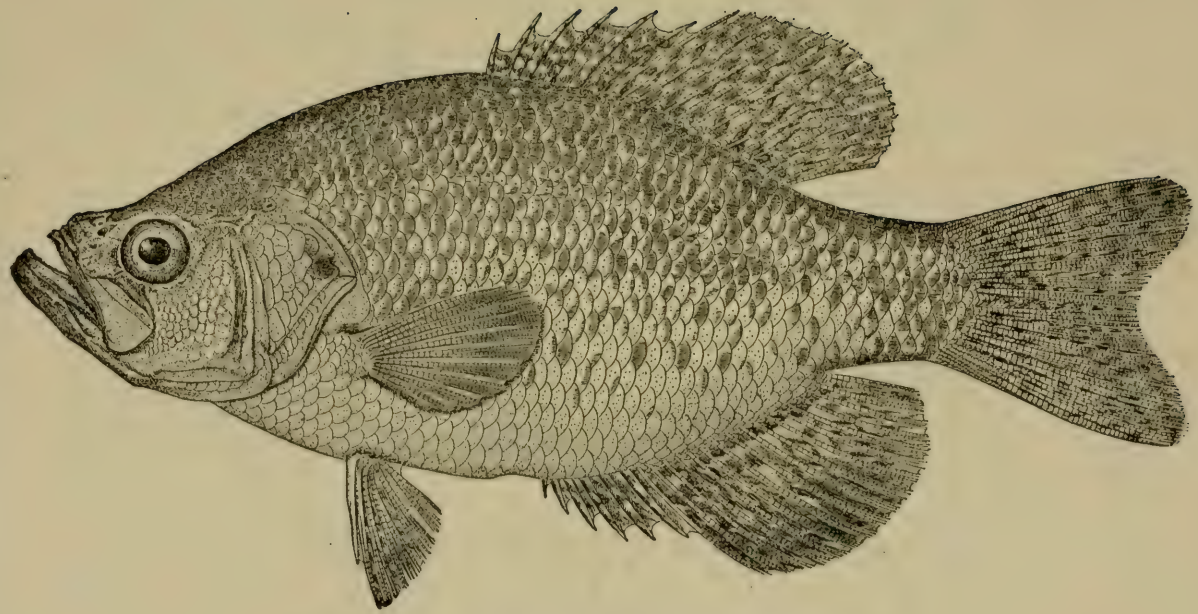
NAMES.

When you know that such names as goggle-eye, goggle-eyed perch—used also for the rock bass—grass bass, strawberry bass, bitter head, lamplighter, bank-lick bass, calico bass and sac-a-lai, are applied to these fishes indiscriminately, as well as crappie, you will agree that it is time for some one to take hold and straighten out the tangle, and this I have undertaken in the hope that in time the names I have suggested will stick.

VALUE OF THE CRAPPIES.

The State of New York has distributed a few small mouth crappies under the absurd name of "strawberry bass," but they should be in every pond where there are no trout, but where perch and sunfish abound. They have been neglected because we have a wealth of such fishes and no writer has presented the claims of these to the angler and fishculturist, if we except the late Prof. Kirtland, of Ohio, who said of the small mouth crappie, using the local name:

"The 'grass bass' has not hitherto been deemed worthy of consideration by fishculturists; yet, from a long and intimate acquaintance with its merits, I hesitate not to pronounce it *the fish for the million.* [Italics are Dr. Kirtland's.] It is a native of our Western rivers and lakes, where it usually resorts to deep and sluggish waters; yet in several instances, where it has found its way into cold and rapid streams, and even small-sized brooks, by means of the constructing of



BIG-MOUTHED CRAPPIE (*Pomoxys annularis*).

canals or by the hand of man, it has adapted itself to the change, and in two or three years stocked to overflowing these new localities. As a pan. fish, for the table, it is surpassed by few other fresh-water species. For endurance and rapidity of increase it is unequaled. . . . The grass bass is perfectly adapted to stocking ponds. It will thrive without care in very small ponds of sufficient depth. . . . It will in nowise interfere with the cultivation of any number of species, large or small, in the same waters. It will live harmoniously with all others, and while its structure and disposition restrain it from attacking any other but very small fry, its formidable armature of spinous rays in the dorsal and abdominal fins will guard it against attacks of even the voracious pike."

As the food of the crappies is the same as that of the sunfishes and all other fresh-water fishes with compressed sides, *i. e.* small fish, crustaceans, insects and their larvæ, we must consider that their destructiveness is that of their class. I do not know of a fish, in America or on any other continent, which takes no animal food. When the carp was introduced into America it was heralded as "a sheep among fishes," which grew to great weight on vegetation alone. It is true that the carp eats much vegetation and is fond of that green conferva which ignorant people call "frog spittle," or "frog spawn," with which the frog has as much to do as the editor of "Forest and Stream has," but the carp also loves worms, insect larvæ, and will take a small fish if the fish can't escape.

There may be fishes which are strict vegetarians, if so I don't know them. The brook suckers love trout eggs and work the mud for insect larvæ; the stur-

geons mouth over mud for the snails and other animal life which they get, and we must only consider the question of how much and what kind of animal life a fish consumes in order to plant it in our lakes and streams.

Speaking as a fishculturist, I would, if I could, exterminate every pike, pickerel and mascalonge in the waters of the earth, for the reason that their diet is exclusively fish, and they consume a hundred times their weight in other fishes and then are not as good for the table as some that they have eaten.

As an angler, I take no note of what it costs in good food fish to raise a pike to ten pounds weight, if the pike will only condescend to take my hook. This is a logical appeal from Philip sober to Philip drunk. As a fishculturist, the ratio of food consumed to value of fish for market is a vital one, as much so as the growing of horses, cattle, pigs and poultry is to the farmer; but when my fly is cast, or a baited hook is spinning astern, there is an *alter ego*, another self, watching for results, and the latter fellow never stops to consider whether his catch is worth all the food it has devoured to enable it to pull down the scales to a creditable point, or whether the balance is on the other side. As a fishculturist, I would like to exterminate the whole pike family—pike, pickerel and mascalonge; but as an angler, thinking only of personal sport, the point of view differs.

HABITS.

Although not a climbing fish, like that peculiar perch of India which ascends trees, yet the crappies are often found in tree tops, when the trees have fallen

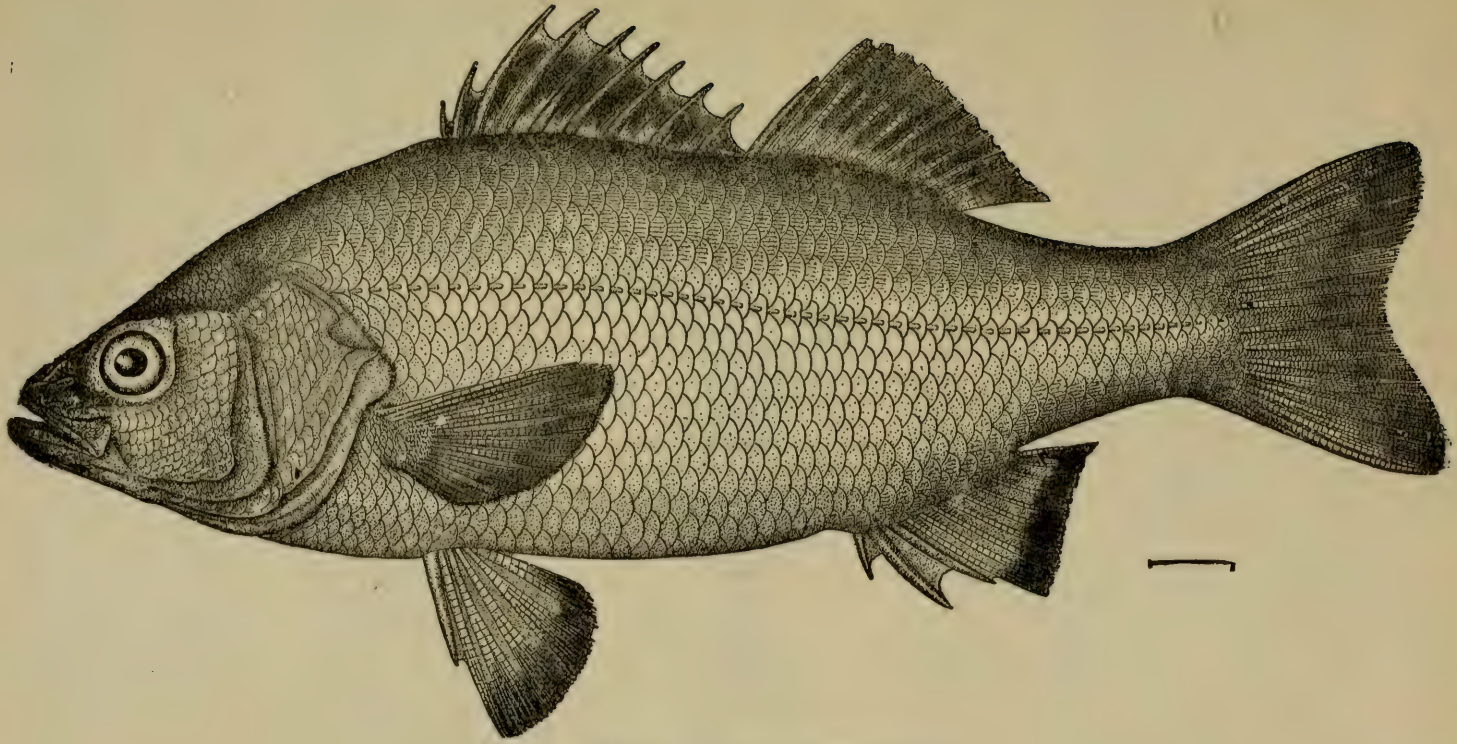
into the water. Here they find protection and food; the limbs are the abode of snails, crustaceans and worms of various kinds as well as of small fishes, for the crappies are omnivorous in their tastes. The preference of the small mouth for clear and colder waters has been alluded to, but as many lakes have both grassy and muddy spots, they afford homes for both species.

I have taken the small mouth crappie in springholes while standing on the ice, but they were dipped up with a net, and I don't know if they would take a hook in winter. This was in Grant County, Wisconsin, in 1857, and we wanted fish for the table. This is told in detail in "Men I Have Fished With," page 309. There were black bass there at the time, and they sometimes lie dormant in winter, while the pike and the perch feed the year round. I have fished through the ice with small minnows for bait, and where crappies were plenty, but never took one. This, however, does not prove that they do not feed in winter.

CHAPTER XXVII.

WHITE PERCH (*Morone Americana*).

This is a good little fish often seen in New York markets. It is not white, but is a light olive on the back and a little lighter on the sides. It is found in brackish waters on our eastern coast from Nova Scotia to South Carolina. It ascends rivers and spawns in fresh water. It is often land-locked in fresh-water



White Perch (*Morone americana*).

ponds and breeds there. It rises to the fly quite well and grows to the length of ten inches.

It spawns shortly after the ice leaves the ponds and attaches its eggs to floating sticks, weeds, etc. They spawn in early morning at the surface and make quite a splashing. I have obtained the weeds bearing the eggs and hatched them in McDonald hatching jars. The eggs are very small.

CHAPTER XXVIII.

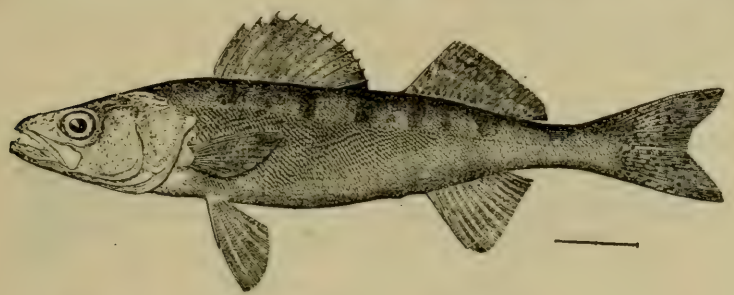
THE PIKE-PERCHES.

Here are two more fishes plagued with a multiplicity of common names. I follow the late Dr. George Brown Goode in choosing the above title, and he was one of our best authorities. The old name of *Lucioperca* given by Linnæus means *Lucius* a pike, and *perca* a perch. It was a perch with the habits of the pike. There are two species; the largest and most important one resembles the only European species. This is commonly known as "wall-eyed pike," from its large glassy eye.

THE WALL-EYED PIKE (*Stizostedion vitreum*).

This fish ranges from the Great Lakes through the small lakes of western New York, north through British America and south in the Susquehanna, Ohio and

rivers in western Virginia, North Carolina and Georgia. "In the upper lakes, where the true pike *Esox lucius* is known as the pickerel, the *S. vitreum* is called the 'pike,' with such local variations as 'blue pike,' 'yellow pike,' 'green pike' and 'grass pike.' In Ohio, Tennessee and western North Carolina it robs *Esox* of another of its names and is called a 'jack.' In Lake Erie, however, it is generally known as 'pickerel.' The name 'salmon' is quite generally applied in rivers where no member of the *Salmonidæ* is found. This is notably the fact in the tributaries of the Mississippi, Ohio and Susquehanna. 'Okow,' sometimes heard in



THE WALL-EYED PIKE (*Stizostedion Vitreum*).

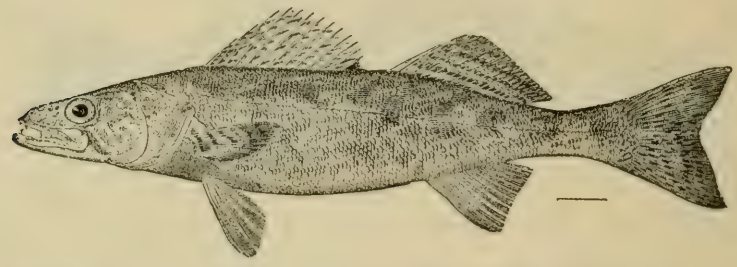
the lake region, is evidently a corruption of 'okun' and 'okunj,' Polish and Russian names for the common perch. The French Canadians on the lakes call it 'doree,' and 'dory' is a name which has found its way into books. . . . The name 'wall-eyed pike' is coming into favor and has already replaced some misnomers long prevalent. If it must be used, 'wall-eye' is of course to be preferred to the misleading 'wall-eyed pike.' To me it seems a most repulsive and undesirable name, but others find it appropriate."—GOODE, "American Fishes."

The wall-eye grows to a weight of thirty pounds or

more, and is distinguished from the other species by its larger eye, a black blotch on the last part of its first dorsal fin. In the illustrations of the "Fisheries Industries" from which my cuts have been taken, the wall-eye is called by the name of the other fish; somebody blundered. Goode has them correct.

THE SAUGER (*S. canadense*).

This is a smaller fish and is not classed as a "hard fish" on the Great Lakes, but is placed among the inferior "soft fish." It has a black spot at the base of the pectoral fins, smaller eye, and rows of spots on its



THE SAUGER OR SAND PIKE (*Stizostedion Canadense*).

first dorsal. It is a more northern species, ranging from the Ohio northward. It is also called "sand pike," which in the plates of the "Fisheries Industries" is misprinted "land pike."

HATCHING WALL-EYED PIKE EGGS.

By James Nevin, Supt. Wisconsin Fish Commission.

To the best of my knowledge, the first pike eggs hatched on the American continent were collected and

hatched by me at the Sandwich, Ontario, fish hatchery, during the spring of 1877. On the first day of April of that year I went to West Bay City, at the mouth of Saginaw Bay, which was the fishermen's headquarters, and where, I was informed, a large number of wall-eyed pike were caught. On the second day of April I went out on a fishing smack, and from four pound nets there were lifted five tons of as fine fish as man ever looked on. I secured about ten quarts of eggs, which, I believe, were the first wall-eyed pike eggs taken in American waters. I continued to work here, going out on the boat from day to day, until I had seven boxes of eggs, which I shipped to Detroit.

The Sandwich hatchery is located across the river from Detroit. I had left a Frenchman named Daniel Semande in charge of the hatchery. Semande was a man who could turn his hand to any kind of work, and he was possessed of the idea that he could hatch fish as well, and possibly better, than any other man in the country. He had been a fisherman all his life. Semande was desirous of trying his hand at hatching these eggs, and said if I would send the eggs to him he would take as good care of them as if I were there to look after them. The eggs were placed in hatching cans. Semande wrote me every day, assuring me that the eggs were "doing fine." Later, however, I received a telegram from Mrs. Nevin, advising me to come home, as there was not a live egg in the batch. I took the first train home, and on arrival found that the eggs were all dead. I had these thrown out, and returned to West Bay City to get another batch. I succeeded in obtaining some ten millions eggs, which I took home with me. From this lot we hatched one million fry. However, I did not feel satisfied with the

result, and was of the opinion I could do better if I could get the eggs for another trial.

On the 16th day of May of the same year I left for St. Clair River, where pike spawn much later than on any other grounds that I know of. Usually they begin to spawn as soon as the ice goes out of the river, lake or bay, as the case may be; but on the St. Clair River they do not begin to spawn until the 15th of May. I succeeded in collecting 20,000,000 eggs on this river, which I took with me to the hatchery. Of this batch we hatched 3,500,000 fry, as is shown by my report for that year, which was a small percentage of the number of eggs taken.

In the spring of 1878 I again went to Saginaw Bay to collect pike eggs. While there I met Mr. Orin M. Chase, of the Michigan Fish Commission, to whom I related my experience and partial failure with pike eggs the previous year. After Mr. Chase had been there a few days he showed me the eggs he had taken, and said: "Jim, I will hatch 90 per cent. of these eggs." I told him I would call around and see his eggs before they began to hatch. Mr. Chase left for the Detroit hatchey with his eggs; at the same time I started for the Sandwich hatchery with those I had taken. Just before the fish began to hatch, I visited the Detroit hatchery to compare notes with Mr. Chase. Mr. Chase told me, "The jig is up; I will not hatch five per cent. of the eggs I took." I secured that season from Saginaw Bay and St. Clair River 50,000,000 eggs, and hatched and planted 6,000,000 fry from those eggs.

The difficulty in this work was the adhesiveness of the eggs. We could not keep them from sticking together. For days after they were put in jars they

would bunch up, and we had to take them out two and three times per day, and perhaps oftener, and run them through a wire screen with a mesh just large enough to permit the eggs to pass through one at a time. We killed a large part of the eggs in handling them and working them through the screens.

After I came to Wisconsin, for three years we collected our pike eggs at the mouth of the Wolf River. We took from 150,000,000 to 200,000,000 eggs each year; but were able to hatch not more than 5 per cent. of this vast number. The difficulty here was that the milt came from the male fish in clots and would not dissolve in the pan. After trying different methods to overcome the difficulty, but without success, we decided not to collect any more eggs at that point. Three years ago I was ordered to plant some full-grown pike in the lakes at Waupaca. For convenience in transportation, Gill's Landing, a railroad station some twenty miles up the river from where we had taken eggs, was selected as the place to get the fish. To our great surprise, we found the male fish here in prime condition. We took a quantity of eggs and hatched fully 60 per cent. of them. The only hypothesis on which I can account for our failure to impregnate the eggs at the mouth of the river is that the male fish were not ripe when they entered the river.

For several years we have collected eggs from Pike Lake, in Price County. This lake is situated in the pine forests, twenty-four miles from a railroad. A hatch of 50 per cent. is a large average; but we have impregnated fully 80 per cent. of the eggs taken from this lake. The fish are of the large yellow variety; the male will produce more milt than a dozen males from any other waters in which I have collected eggs.

The eggs from different localities vary in size. Those from fish taken from Pike Lake will average 80,000 to the quart, while those from fish taken from the Wolf River, Green Bay, Saginaw Bay or St. Clair River will average 120,000 to the quart.

The course which we pursue in collecting, fertilizing and hatching the eggs is as follows: We get on the grounds early and have all preparations made for tne fish when they come. The males come a few days ahead of the females; but we have our nets set and corral a large number of males, which we keep until the run of female fish comes on. They are caught in pound or fyke nets. The nets are lifted morning and evening, and the fish taken in live boxes and placed in crates, which we have prepared for the purpose. Thus, when we begin to take spawn, the fish are convenient to the spawn taker. A man with a net dips the fish into a tub. The spawn taker takes a ripe female from the tub and spawns it into a pan containing less than half a teacup of water. As soon as the female is spawned the male fish is used. Only one female fish is spawned into a pan—a fresh pan being provided after each. One man attends to the pans. After each female has been stripped and enough milt put on the eggs, he shakes the pan for a moment to mix the milt and eggs, and then sets it aside for some twenty minutes until the eggs become loose. When we get eight or ten pans, or enough for a tub-full, they are washed and separated in a tub in the following manner: We procure a quantity of clay or muck, as is most convenient, which we usually sift to remove lumps and gravel, and mix it in a tub of water. The eggs are then placed in a tub, and a man or boy with a dipper keeps them in constant motion in the tub, pouring off

part of the water at intervals of five or ten minutes and adding fresh water. This is continued for an hour, or until the eggs become hard and will not stick. They are then placed in boxes, similar to shad boxes, and set in the current of the river, where they are kept from one to six days, or until convenient to ship them to the hatchery. In shipping the eggs, they are placed on wire trays and put in boxes, which are large enough to permit two inches of crushed ice to be packed on every side. We also put crushed ice on the top tray. Our trays are made of galvanized wire-cloth. Most hatcheries use flannel cloth on the trays. We have discarded the flannel-covered trays, as we believe the wire-cloth is preferable for the reason that they are more durable, the water drips through the wire more readily than flannel, and a better circulation is provided. When the eggs are received at the hatchery they are taken from the shipping boxes and run through a wire screen with a mesh just large enough for a single egg to pass through at a time. This screening removes all scales or dirt from the eggs. They are then put in hatching jars, and they work as freely as the eggs of the whitefish.

We have used muck and clay in our eggs to prevent adhesion since the spring of 1884. This method of preventing adhesion of the eggs was discovered by us accidentally. We were having the usual trouble with our pike eggs, and they were badly bunched up in the jars. One day it became necessary for the city to repair the water main which supplied our hatchery. As a result we had a flow of roily water for several hours. After the roily water had cleared off it was evident that our eggs were working much better. This set us to experimenting. We procured some earth, took our

eggs out of the jars and put them in tubs filled with muddy water. We stirred them in the tubs for several minutes and returned them to the jars. To our great delight, the experiment was completely successful; and from that day to this we have had no trouble in preventing these eggs from sticking or bunching.

The wall-eyed pike is a fish which will not stand much confinement. If they are kept in the crates more than three days before the time to spawn, the eggs will begin to bunch in the fish and will not loosen up; or the tail of the fish will become fungused and the fish will soon die. When we see a white spot back of the second dorsal fin we at once liberate the fish.

I have been engaged in the work of fishculture for twenty-seven years, but until last spring it remained for me to see these fish in the act of spawning naturally. It was during high water; the stream had overflowed its banks and they were scattered over the marshy land adjoining. I stood on a railroad trestlework for an hour and watched hundreds of them in the act of spawning. The female would roll over and over constantly during the time she threw her eggs, while from two to five small male fish gathered around her and gave off milt as the eggs came from the female. I have often heard men say that the time to go spearing with a jack-light was when the fish were rolling or bunching, as they could then get two or three fish at a throw. I can now fully understand the significance of the statement.

I use the Chase hatching jar for hatching these fish. The term of incubation varies with the temperature of the water used in the jars. In water of 60° the eggs will hatch in about fifteen days; in water of a temperature of 48° it requires thirty-five days to

hatch. It takes but a few days to absorb the sac; this also depends to a great extent on the temperature of the water. After the sac is absorbed the fry should be liberated as soon as possible, or a considerable loss will be incurred by the little fellows devouring one another.

In the above paper Mr. Nevin has covered the ground very well, and it only remains to say that Prof. Reighard, of Michigan, in experimenting with these eggs, obtained excellent results in overcoming the adhesiveness by the use of cornstarch.

CHAPTER XXIX.

CATFISH.

These fish, called "bullheads" in New York and "bullpouts" and "hornpouts" in New England, are very good table fish for many people. They feed on the bottom on worms, fish eggs, or any animal food. As they feed mainly at night, they may forage on the nests of the black bass; but as this is the first time that such a thing has been hinted, I hasten to say that it is merely a surmise. This family of fishes protect their young.

Of catfishes we have two salt-water species and sixteen in fresh water, from the great *Amieurus nigricans,* which grows to 100 pounds weight, down to small ones which do not get to be over four inches in length. The common "bullhead" of New York, *A. nebulosus,* grows to a length of eighteen inches and ranges from New England to Wisconsin, Virginia and Texas. The best of all the species for table is the "channel cat," or "white cat," *Ictalurus punctatus,* which grows to three feet, and is thus described by Jordan: "Oliveaceus, rarely blackish, the sides silvery, almost always with small round dark olive spots; eye large, not wholly in front of middle of head; mouth small; barbels long; spines strong, serrate; Montana to Vermont, Georgia and Mexico; very abundant in flowing streams. A handsome fish; the best in the family as food."

The *A. albidus* of the Potomac is also called "white cat" and "channel cat." It has a stout body and broad head and is not spotted. The common names should not confound the species. They guard their nests.

Fin rays soft with a stout pungent spine in the dorsal and pectorals. In the latter fins these spines can be set at right angles to the body and locked so that they may be broken before they can be pressed down. There is a sort of trigger-bone behind these pectoral spines which, if touched, allows them to be laid back. In former years, when inspecting the commercial fisheries on the Hudson, I discovered this and the knowledge was of value in getting a "bullhead" from a gill net where it was entangled.

CHAPTER XXX.

CARP (*Cyprinus carpio*).

The indiscriminate introduction of this fish in America was a mistake. It was boomed as a great producer of good food where no good food grew. It was a vegetarian, "a sheep among fishes," quick growing and prolific. All of this is true. The fact is that in Germany fish are a luxury and poor people do not eat fresh fish. Before the day of railroads fish that reached Berlin came by stage coach, and to-day the people are prejudiced against all salt-water fish, which they say has "a sea taste." This is hereditary prejudice and prevents good sea fish from going to Berlin in large quantities. They want their fish alive, and the fishmongers have most of their fish in aquaria. Fancy this for the thousands of tons that come to New York daily! In the streets of Hamburg can be seen tubs with pike "hecht" (*esox*), perch (*barsch*) and carp, all kept alive by women aerating the water.

We must remember this in order to understand why the Germans consider the carp a good fish; they know no better. They have "improved" breeds of them as they have of cattle, from the fully scaled fish to those partly naked but with big scales accidentally placed, *mirrorkarpfen*, to those without a scale, *lederkarpfen*.

The late Herr von Behr, President of the German Fishery Association, induced Prof. Baird to import the carp and eulogized it. Prof. Baird did so, and to-day no fish is so heartily cursed by Americans as

the carp. It roots up the water plants, muddies the ponds and renders them unfit for other fish, and the carp are worthless for the table. They are in the class of the soft buffalo fish of the Mississippi, and the suckers.

Great carp of fifteen to twenty pounds come to Fulton Market, New York, and some Germans, with old country memories, buy them; a lot are sold by push cart men among the tenements on the East Side, but there is little sale for them outside of this. I have eaten the carp in Germany, cooked in beer and served with a brown beer sauce, but never when I could help it.

The carp spawn in early summer, the eggs adhering to water plants. The fish grow fast, under favorable circumstances reaching a weight of ten pounds in three years. The Government carp ponds at Washington, D. C., overflowed some years ago and let a lot of these fish into the Potomac, and the shad fishers and anglers are cursing them to-day for a nuisance that can never be abated, like our European sparrow.

It is a significant fact that the United States Fish Commission published "A Manual of Fish Culture" in 1897 and did not mention the carp.

CASTRATING CARP.

Here is a curious bit of fish lore translated from the "Deustche Fischerei Zeitung, Stettin, of May 16, 1882, under the above heading: "Concerning the question asked by Count Gessler about the castration of carp, I will quote from an old German fish book entitled "Pond and Fishery Husbandry," by Johann Andreas Guenther, 1810, pages 142-144. 'To bring the carp to

a high degree of fatness, and also to make their flesh of finer flavor, the Englishman, Tull, has discovered and recommended castration. This operation can be performed on the male as well as on the female. The best time for the operation is after they have spawned, while they are soft and feeble, for then the painful effects are not so lasting.' "

There was more of this, but no detail, and I wrote Count Max von dem Borne, a well known German fish-culturist, and here is his reply:

"Berneuchen, March 9, 1881.

"My Dear Sir: I have your letter of March 1, and will try to collect something relating to the castration of carp, which is entirely unknown to me. Therefore I have written to Mr. W. Horak, late Director of the large carp ponds of the Prince Schwarzenberg, at Wittingen, and the author of the best book on carp breeding. I hope he will give us all ever known on the subject."

This was all I ever heard of the matter, until the late Prof. Spencer F. Baird wrote me, under date of May 20, 1886: "Mr. Hessel informs me that the Bretaigne carp is the caponized ordinary carp, requiring of course a special process to produce this result. * * *."

CHAPTER XXXI.

THE ALEWIVES.

These are near relatives of the shad, but having glutinous eggs are widely separated in this book. They

are called "herrin" on the Hudson River, but the true herring, *clupea harengus*, does not enter fresh water. We have the "branch herring," *c. pseudoharengus*, and the "glut herring," *c. æstivalis*, both of value. They are bony, but are eaten fresh and salted in great numbers by people living on the rivers. They spawn at night in creeks and bayous, among the flotsam, and make a great racket in doing it. I have taken the eggs on dried eel-grass and hatched them in floating boxes. It was the milt of one of these fishes that was used on shad eggs when no male shad were at hand. They run up the Hudson to Albany, and I have seen them by the thousand in a pool below the dam of the South Side Sportsman's Club, on the south side of Long Island, and intended to bring them to the little smelt stream at Cold Spring Harbor. They are not first-class fish, but are good food, and that is what poor people want. Like the shad, they get their living in salt-water, and, therefore, do not compete with the fresh-water species. As food for people who want a cheap food this species should be cultivated where there are facilities for its breeding. Below Albany, N. Y., they come soon after the ice goes out and at first retail readily at 30 to 50 cents per dozen. A month later, when they are plenty and are about to spawn, or have spawned, the price drops to 10 cents per dozen, and the farmers drive into the river where the shad fishermen are hauling seines and take home wagon loads for salting, buying them for a few cents per bushel. At least that was the rule when I was hatching shad on the Hudson, at Castleton, in 1874, and later.

CHAPTER XXXII.

STURGEON.

This valuable food fish is in danger of extermination by being caught in the spawning season for its partly ripe eggs, which, owing to the demand for them when made into caviare, are worth more than the great fish itself. I am unfashionable enough to like sturgeon and to loathe caviare; if there was a stronger word than loathe it would be used here.

Once the Hudson River swarmed with this fish, and "Albany beef" was the common name of its flesh. Now they are practically gone from the river and the caviare hunters have gone to Lake of the Woods, north of Minnesota, for the lake sturgeon, for there are two species.

The sturgeon spawns in early summer, has heavy, adhesive eggs, measuring nine to the inch, which hatch in six to seven days. The eggs are difficult to take and in some cases the fish of both sexes have had to be ripped open, even when ripe.

CHAPTER XXXIII.

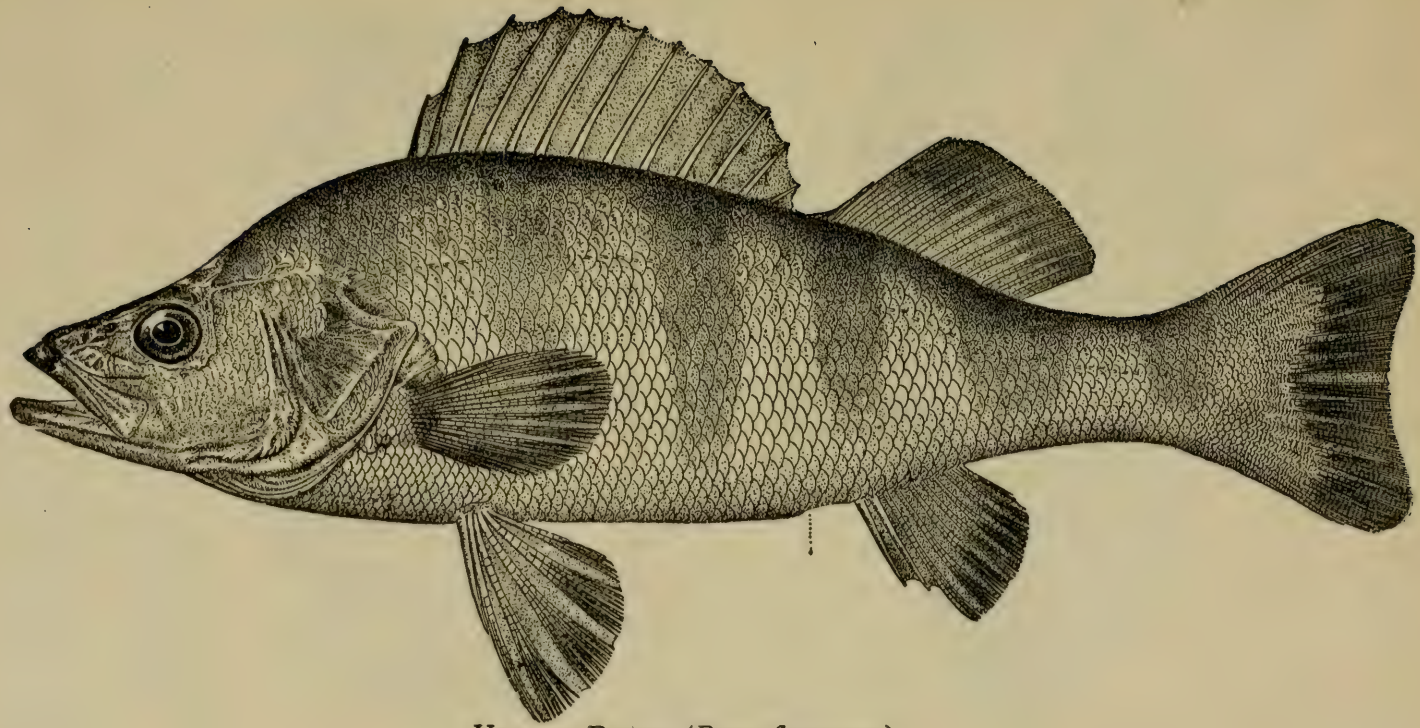
YELLOW PERCH (*Perca flavescens*).

This common pond and river fish is so near the European perch that the fish sharps have disputed over

it for years. Jordan gives its range in America as "Minnesota to Northern Ohio and Quebec, south to South Carolina, east of Alleghanies, not in Ohio Valley or Southwest; abundant." He also gives its length as fifteen inches. It is too common to describe. Is not found in Adirondack waters. The black stripes on yellow ground have given it the names of ringed perch and raccoon perch in some parts. It is a fair table fish, and if from muddy, weedy waters, should be skinned; in fact, black bass are better when skinned.

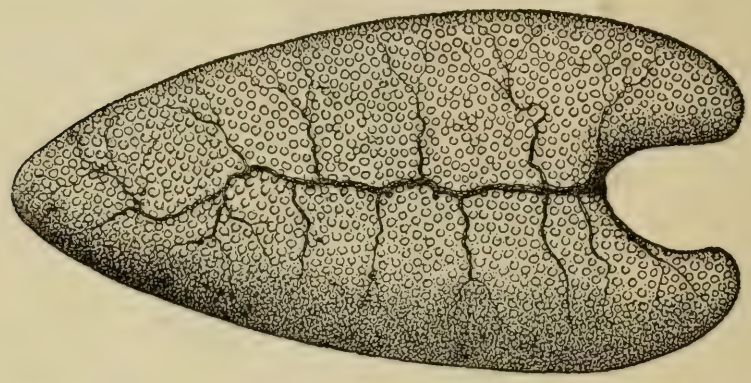
The eggs of this fish are unique. It is the first fish that I hatched and I find the following among my notes: "April 20, 1868, while fishing a few miles below Albany, took and impregnated 10,000 spawn of the yellow perch. The spawn comes in a long ribbon, or rather a cylindric one, double like a stocking leg, but with numerous wrinkles; the eggs are seen as bright spots the size of a pin head scattered through this mucous mass. The spawn was partly pressed and partly pulled from the fish and put into the old wash basin used as a boat bailer with water, and the milt from several males put with it. Took it to Albany in my dinner pail, and remembering that the aquarium at the State Geological Rooms was empty, I asked permission to use it for hatching, which request was kindly granted by Prof. Hall, Curator of the State Cabinet. Noticed life the third day; about 100 dead—all dead by May 1, don't know why.

"I found that this fish hung its spawn over twigs under water, and have found it often hung in the nets. Have often seen it hanging high and dry at least a foot out of water, where it was laid at a higher stage of the river. My spawn was hung on a twig near where the water entered the tank to insure a circulation.



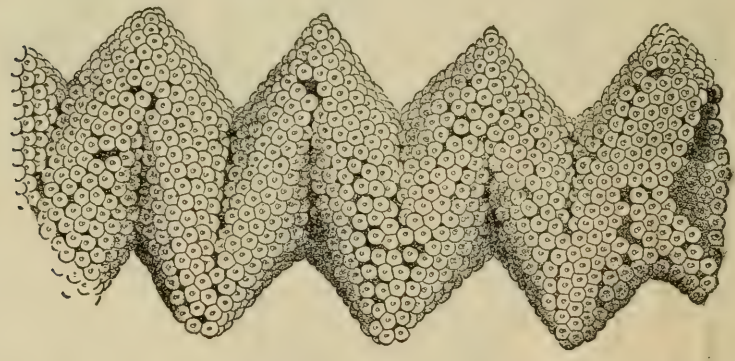
YELLOW PERCH (*Perca flavescens*).

"May 2, took about 20,000 and put in same place; raised the curtain, but the sun did not strike the eggs;



Ovary of Yellow Perch, with nearly ripe eggs, the forked extremity being the anterior part of the roe.

life in two days. Some one let down the curtains and pushed down the strainer on the waste pipe; about two-thirds of the eggs went down the pipe (it was in



Part of a Recently Laid Mass of Yellow Perch Eggs. These cuts are from "A Manual of Fish Culture," extracted from U. S. Fish Commission Report for 1897.

three bunches), half the remainder dead, probably from handling, as I was informed that somebody lifted them out. The embryos are in constant motion in the egg—

a regular beating movement like clockwork. In ten days from impregnation 1,000 hatched from the 3,000 left, notwithstanding the eggs were often disturbed by visitors. Six days after hatching, the sac was absorbed, and I fed them clotted blood every day. My notes say: 'In twenty days they had all disappeared down the waste pipe.' "

The ice is scarcely out of the rivers before the perch begins to spawn, and in tide water millions of eggs perish by being left in the air at low tide, or after a freshet. The mass of eggs is often larger than the fish which laid them, after they have swollen, being sometimes five feet long. The only provision that can be made for their spawning is to put bushes in the water if there are none there. The eggs may then be gathered and hatched in any suitable water between 45° and 50° Fahr.

I have since hatched yellow perch on Long Island; the water there was colder than that in Albany, and the hatching required a few days more.

SECTION VI.

PARASITES, DISEASES AND ENEMIES.

There are thorns in the path of the fishculturist, who must be as vigilant as the farmer, manufacturer or merchant in order to preserve the fruits of his labor. Outside of human poachers, he must watch for the three plagues which are treated of in this section. By day and by night there are enemies working against him, as there are against the grower of fruit, grain, live stock or the man in other business. Eternal vigilance is the price of success in fishculture as well as in all other things.

CHAPTER XXXIV.

PARASITES.

All living animals have internal and external parasites, unless the parasites themselves are exceptions, which may be a matter of doubt, for an old rhyme says:

"So naturalists observe, a flea
Has smaller fleas that on him prey;
And these have smaller still to bite 'em;
And so proceed, *ad infinitum*."

EXTERNAL PARASITES.

A deadly parasite is the fungus which is called *Saprolegnia ferax* by scientists, although the microscope shows variations which may be different species. Of this I am not qualified to speak. It appears to be nearly the same on the fish as on the egg, a woolly or cottony growth. We often see it on dead flies in water, and the fact is that spores of this fungus are everywhere in the water, only awaiting a suitable field to grow in, just as spores of mould in the air will find a good field in a pair of damp boots in a dark closet, while spores which fall on dry boots will not germinate. An abrasion on the skin of a fish, a bruise or other injury, is an inviting field for fungus, but a clean cut does not seem to be so favorable for its growth.

A favorite spot for this fungus to germinate is where the protecting slime has been removed from a fish, and this slime is readily removed by a dry hand, hence in the chapter on taking trout eggs I insist on the hands being wet before the trout is touched. It is not uncommon to find a dead fish with the print of a thumb on one side of its back and of the fingers on the other, where some kind angler has returned a fish to the water after handling it, in ignorance that he signed its death warrant when he touched it with a dry hand. You may take a fresh-water fish of any kind and lay it in a dry towel, smoothing the towel gently about it and then return the fish to the water, when it will swim off apparently unharmed; about a week afterward the fish will appear to have a bloom, like that of a ripe purple grape or plum upon it, and then comes the "cottony

growth," and in ten days the fish will be dead, with great inflamed patches below the skin where the fungus has rooted into the flesh.

In the first stages of this trouble the fungus can be killed by keeping the fish in salt water for a week or two, but when the roots penetrate below the skin and attack the muscle there is no remedy known at present. In the old New York Aquarium, Broadway and Thirty-fifth street, New York, 1876-79, I tried salicylic acid, borax, boracic acid and alum, separately and combined, with no effect on the mascalonge and other fishes injured in transit. The last three things named are deadly to fish if not carefully used, and I went so far as to bandage the fish and put it in a trough where it could not turn, and then apply the remedies behind its mouth and gills, saturating the bandage, but found nothing as good as salt and clean soil. By "clean soil" I mean earth from the country, and not city mud. All trout streams have more or less soil washed into them at times, even to rendering the water opaque, but it never injures trout, on the contrary it does them good in freeing them from external parasites.

A formidable external parasite common to most fishes is the lamprey in its different species. These animals are often miscalled "lamper eels" and "lamprey eels," but they are not remotely related to the eel, or even in the class *pices*, which contain the fishes, where the eel is entitled to a place. They are in the class *cyclostomi*, and are nearer worms than fish, except that they have a soft backbone. Jordan, "Manual of the Vertebrates," says of them: "Skeleton cartilaginous; skull imperfect, not separate from vertebral column; no jaws; no limbs; no ribs; no shoulder girdle nor pelvic elements; gills in the form of fixed sacs, six

or more on each side; nostril single median; mouth sub-inferior, nearly circular, adapted for sucking; heart without arterial bulb; alimentary canal straight, simple; vertical fins with feeble rays. Naked eel-shaped animals found in all cool waters."

Yet when I testified in court as to the species of eels in our waters, I was followed by a man who claims to be an authority on fishes, who mentioned the "lamper eel" as an eel. Jordan says: "They attach themselves to fishes, and feed by scraping off the flesh with their rasp-like teeth." An exhaustive and well illustrated paper on this subject may be found in the Bulletin of the United States Fish Commission, Volume XVII., 1897, pages 209 to 215, by Prof. H. A. Surface, M. S., Fellow in Vertebrate Zoology, Cornell University, under the title of "The Lampreys of Central New York." The illustrations show the lampreys, and photos of pickerel, suckers and catfish with great holes in their sides, where they had been eaten. Lampreys have the habit of leeches.

The same volume, pages 193, 199, contains an article entitled "An Economical Consideration of Fish Parasites," by Dr. Edwin Linton, Ph. D., Professor of Biology, Washington and Jefferson College. The reader who wishes to pursue the subject further is recommended to get the volume named.

In 1886 Mr. C. Van Beuren, President Balsam Lake Club, Hardenburgh, Ulster County, N. Y., wrote me: "A number of trout have been caught in our lake with black spots on them. These spots are not very numerous, perhaps a dozen on one fish. They are on the back, sides, fins and tails, and they feel like shot under the skin. We have examined the spots under a microscope and find them, as viewed by the eye, to be 1-32 of

an inch. The microscope shows them to be a cell containing an egg with a living embryo. The egg is about 1-200 of an inch in diameter. As they are on the fins they would seem to come from the outside. Those on the sides of the fish have the egg apparently under the scales and attached to the skin by a thread-like appendage which pulls out on removing the egg. Is this a serious matter?"

I have seen black bass, chubs, sunfish and other species well sprinkled with these spots in early summer, and later in the season found worms in the flesh of the fishes, but they seemed to do no harm, even to people who ate the wormy fish. Somehow I connected the spots and the worms together, but never tried to work the thing out. I never saw them on trout.

INTERNAL PARASITES.

I took a tape-worm thirty-six inches long from a shiner, whose extreme length was 4¼ inches. The fish took my fly while trouting in the Adirondacks, and as it was so unnaturally plump it was opened.

White intestinal thread-worms are often present in trout, and these worms pass from the intestines to the body cavity, and even through the air bladder, after the trout has been opened, but what they do before that can't be seen.

Many parasites of fishes, like tape-worms, do not complete their existence in the fish, but their final host is some bird or mammal which eats the fish, just as the tape-worm of the hare becomes complete in the fox; that of the hog in man, etc.

The trout of Yellowstone Lake are infested with

worms in their flesh. Dr. Leidy described this worm under the name of *Dibothrium cordiceps.*

CHAPTER XXXV.

DISEASES.

English fishculturists, anglers and anatomists are greatly troubled by what they call the "salmon disease." Prof. Huxley said of it: "At first small whitish patches appear on the skin. The smooth integument of the top of the head, or of the end of the snout, is a very usual locality, but the adipose fin and the axillæ of the paired fins are also among the first parts to be affected. If there is an abraded or wounded surface, the disease is pretty sure to attack it, but the invasion of the malady is in nowise dependent upon the pre-existence of an injury. . . . In the scaleless parts of the skin, sloughing soon sets in and deep burrowing sores are formed. . . . If the fluffy, whitish coat which is so characteristic of the diseased skin—and is sometimes tenacious enough to be stripped off in flakes like wet paper—is examined microscopically, it is seen to consist chiefly of a tangled mass of fine filaments on an average about 1-2,000 of an inch in diameter, which are at once recognizable as the stems (or hyphæ, as they are technically called) of a fungus, *Saprolegnia ferax,* similar to those known as moulds."

Prof. Huxley further says: "These observations left no doubt in my mind that the *Saprolegnia* is the

cause and not a mere accompaniment of the salmon disease." I have treated of this in the preceding chapter. Prof. Huxley thus sums up the present state of our knowledge respecting the salmon disease:

"1. The sole cause of the disease is the fungus *Saprolegnia ferax,* which burrows in and destroys the skin of the fish.

"2. This fungus habitually lives on dead organic matter, and only lives in fresh water."

3 and 4 give the mode of propagation of the fungus.

"5. It follows, therefore, that the existence of the cause of salmon disease, or to speak more generally, of the integumentary mycosis of fresh-water fishes, is independent of the existence of fishes; and consequently that the extirpation of all the diseased fish in a river does not involve the extirpation of the cause of the disease in that river.

"6. There is reason to believe that the *Saprolegnia* exists in its saprophytic form in most fresh waters, and that it attacks the fish of most rivers occasionally. In other words, the mycosis of fresh-water fishes is a widespread sporadic disease.

"7. That which it is now desirable to ascertain is the nature of the influences under which the sporadic disease suddenly assumes an epidemic character. On this point we have very little light at present, for although there is some reason for thinking that deficient oxygenation, whether produced by overcrowding or otherwise, may favor the development of the disease, and though it is possible that some kinds of pollution may favor it, yet the disease sometimes becomes epidemic under conditions in which these two predisposing causes are excluded; and it does not always appear when they are present.

"8. Epidemics subside spontaneously, though the fish remain in fresh water.

"9. The productiveness of a salmon river is not necessarily interfered with by even a violent epidemic.

"The last three propositions indicate the moral of my paper—which is to make sure that you know what you are about before meddling with the salmon disease. Until the causes which convert the sporadic into the epidemic disease are known, all interference is mere groping in the dark; and when they are known, it will be a great question whether the preventive measures adopted are worth their cost.

"Fishery doctors at the present day remind me of human doctors in my youth—they were always for doing something. I remember one of my teachers laid down the notable maxim, 'when you are in doubt, play a trump,' and I should think that those of us who have followed this advice, in the last fifty years, must have largely added to the bills of mortality. Our fishery doctors are of the same mind as my friend. They are—or at any rate ought to be—very much in doubt, and yet they continually want to play trumps in the shape of stringent regulations and restrictions. If I might tender a piece of advice, I would say—don't."

After quoting Huxley I can't help asking: If the fungus (2) only lives on dead organic matter why it attacks the living tissues of fish?

A DEAD HORSE.

Years ago a man asked me to come and see what was the trouble with his trout and eggs. As he put it: "There was wool growing all over them." I told him

that I would not promise to find the trouble, and intimated that my honorarium would be $25 and expenses for an inspection. He agreed. His fish were in bad shape; he had hatched trout successfully the winter before and now fungus attacked every dead egg before it had been dead half a day. I tasted the water, but learned nothing from that; looked over the ponds and their inlets without finding anything wrong, and to all his questions merely replied that so far there was no visible cause for the trouble. We went to dinner and I was too worried to eat much. Perhaps this man, whom I had never met before, thought me a fraud, and while my time was valuable to me, I resolved that I would not take his money if I could do him no good. After dinner I proposed a trip to the springs at the head of his little stream. There was a marshy piece of woodland, and in rubber boots we went into it. There, draining into his ponds, was a horse which had died three months before. My advice was: "Haul that horse out and bury it where no water from it will flow into your springs. Get a barrel of quicklime and cover the spot where he lies and also over all the space you may drag him where the surface water may flow into your springs."

He looked astonished and said: "Quicklime will kill trout, and if I do that they will all die. How does that horse, which died last fall, make my trout woolly?"

I told him about the "woolly" growth from dead animal matter and explained that quicklime only killed trout because it was "quick," and that well-slacked lime would not hurt his fish, and that his barrel of lime would be very dead before it trickled through the swamp to his ponds, but would at once kill all the

"woolly germs." He followed the "prescription" and was so well pleased that he sent for me twice again for professional advice—and there is nothing which the amateur fishculturist thinks he needs less than professional advice. He seems to think that because he is a lover of trout or an angler he has been especially endowed with a capacity for the business and can go ahead on some original plan. He makes expensive mistakes and learns in that very dear school. It is a singular thing that a man who shoots and fishes a little thinks he knows more of these things than an old woodsman, and flatters himself that he has the best gun ever made and the best dog ever whelped, and that he is a Daniel Boone, Davy Crockett and Natty Bumpo condensed into one. This is a comfortable and satisfactory belief, but exceedingly expensive when he goes unaided into fishculture, and I speak from a memory of many costly failures when there was no one to instruct. The advice of Huxley is excellent and bears out what has been said in previous chapters.

FISH THAT DIE AFTER SPAWNING.

The salmon fishermen of our western coast believe that their species of salmon spawn but once and die. Some shad fishermen on the Hudson River have the same belief. Because a great majority die, and on the Pacific coast line the shores with their dead, they believe that all die after spawning. I don't believe any such thing. Spawning salmon of from seventy to one hundred pounds have been taken in our rivers emptying into the Pacific, and it is difficult to believe that this was their first trip to the spawning grounds. A

shad will have the nuclei of several successive spawning seasons behind the eggs to be laid when she is caught, and it taxes our credulity to believe th t these are not to be used. Our domestic fowls show nuclei for many settings of eggs; and there the case rests, as lawyers say.

AN EPIDEMIC.

One year I had an epidemic among the trout at Cold Spring Harbor, N. Y. Great sores appeared on the trout and they died by the hundred every day. The Biological Section of the Brooklyn Institute of Arts and Sciences had a summer laboratory there, with students from many parts of the country, and they took the dead fish for study. It worried me into loss of appetite and sleep to see from fifty to a hundred great brook and brown trout, from one to five pounds weight, laid out in the "morgue" every morning for burial, with no idea of the cause of their death. The scientists could make nothing of it, and it was not the fungus called *Saprolegnia.* There was merely a cancer-like sore with broken-down tissue which flowed out of the sores in a pinkish fluid, and that was all.

After a careful investigation I found that some beef livers which came from New York were affected with tuberculosis. I had forbidden the use of any livers which appeared to be diseased, and a year or two before had entertained the idea of complaining to the Board of Health about the tuberculous beef which was being slaughtered, but at that time the problem was, where to get good livers. I finally contracted with a Mr. Abrams to furnish livers that were sound, and after that the disease disappeared. It was not possible

for me to inspect every box of livers which came from New York daily, and in my report to the New York Fish Commission for the year I was at a loss to account for the mortality.

The following circular was issued by me to trout breeders:

"My Dear Sir: During the summer of 1890, a disease which was new to me appeared among the trout in the State ponds under my charge. Both brook and brown trout, large and small, died in great numbers, especially the larger ones of from two to four pounds. I have learned that this was epidemic on Long Island, and in portions of New Jersey, and wish to trace its range, hence this circular is addressed to you in the hope of learning more of its ravages.

"There was no appearance of fungus of the cottony sort, which follows an injury to the skin, with which we are all familiar. The first indication of the disease was a white spot, usually on the side, above or near the anus, of perhaps an inch in diameter. Within ten days a hole would appear in this and shortly afterward the fish would die. Then it would appear that under the skin a patch of dead and decomposed tissue was found, three to four inches long by one to two inches wide, and on the slightest pressure this would spurt out a dark fluid. Under the microscope only broken-down tissue in a state of partial fluidity, with blood corpuscles, could be seen. To my unprofessional eye it more nearly resembled a severe case of Epithelioma, or skin cancer, which I once saw on a man. The disease appeared in May and continued into August, but as nothing was to be gained by letting the matter get into the newspapers it was kept quiet.

"I now wish to mention this epidemic in my next reports to the State and to the United States Fish Commissions, and will feel obliged if you can give any information concerning it; its character, time of appearance and departure, and extent of territory over which it extended, with the privilege of using your reply for publication over your name. I can say that during an experience in fishculture covering nearly a quarter of a century no such disease among fishes has been observed by me, nor has it been recorded by others, to my knowledge.

"Believing that our combined experience may possibly be of future use, anything which you may say on this subject, if such a thing has ever been brought to your notice, will be of value.

"Very respectfully yours,

"FRED MATHER."

Dr. Bashford Dean and Dr. Stratford, of Columbia College, and several other men eminent in the study of animals in health and disease had never seen nor heard of anything like it. Prof. H. W. Conn, of the Wesleyan University, Middletown, Conn., thought that it was caused by bacteria. These forms were present, as they always are in diseased tissue, but whether they were the primary cause or not Prof. Conn did not care to say.

Our ponds were clean, and as there is no chance for pollution above us, the cause was to be looked for beyond foul water. Sometimes a trout would be suddenly seized with a spasm, or giddiness, and would rush about on its side without seeming to know where it was going, and this, with the questions of summer visitors, who asked to know what I could not tell them,

made me wish that there was a wall about the place that even I could not get over. My orders were not to let a visitor see a dead fish; but the fish would die in their sight, and one dead fish is more interesting to a visitor than a thousand live ones, for it affords a chance for questions that no man can answer.

Even in a hatching trough thirty thousand live and healthy fish will not be noticed by a visitor if a dead one is to be seen. A statement that out of the same number of pigs, colts, chickens or children the death rate would be as great, if not greater, brings it squarely to them; but during the epidemic, when a dozen or more large fish were seen belly up, there was only one thing to do, and that was to have a man to keep visitors interested elsewhere while the dead were being taken out and buried.

Although the loss was not, pecuniarily speaking, a personal one to me, yet no man ever felt more disappointed at seeing the results of his labor swept away than I did. My long experience in fishculture furnished no antidote to counteract the poison that was more than decimating the stock which I had carefully reared, and on which my professional reputation hung. Many a time a husky voice belied an assumed indifference as I told a man to "bury 'em in the geranium bed, 'twill make 'em bloom in the fall," but at night the question, "Is this station which I selected and have tried to build up a failure?" was annoying beyond expression.

During the summer of 1891 only one fish manifested any sign of this disease, and it was buried in July. The summer was an exceedingly good one for both fry and adult fish, and the losses in each class were small.

From many answers received in 1891, I quote the

following, which show where the disease was unknown:

"Never had in our State hatcheries any epidemic except among fish less than six months old."—C. S. White, Fish Commissioner of West Virginia.

"We had no disease at the South Side Club, such as you describe last year. Our large trout were remarkably healthy. The great loss in old fish is during and after the spawning season; not only those suffering from fungus on wounds received in fighting, but many seem to have died from no apparent cause. In the winter of 1889-90 the loss was heavier than ever before. This season it was light."—Roland Redmond, President South Side Sportsman's Club. *

Neither was the disease observed at Eastport, L. I., according to Dr. H. G. Preston, President of the Oxford Rod and Gun Club, in the ponds of the club at that place, some thirty miles east of the South Side Club.

The following persons have seen more or less of this epidemic, or one similar to it:

"While I was an employee of the State Hatchery at Caledonia, N. Y., in 1883 or 1884, the large trout died off by hundreds in the summer, with a disease, I should say, similar to the one that you mention. It could not have been the common fungus, which is usually caused by an injury to the skin. I used to pick out the trout every morning, or assist in doing so, and I believe that if not the same disease, it is closely allied to the one of which you speak, and I noticed that there was considerable dark fluid oozing from many of them."—John G. Roberts, Supt. Adirondack Station N. Y. Fish Commission.

* This club is at Oakdale, on the south side of Long Island, and distant from our ponds, on the north side, about twenty-five miles in a direct line. F. M.

Mr. E. F. Boehm, now Superintendent of the State hatchery at Newton's Corners, N. Y., was in the Caledonia hatchery with Mr. Roberts, and writes practically the same thing.

"Six years ago, about the same disease appeared among my trout from April to July. In June they died in great numbers, from twenty-five to thirty every night, and I was discouraged. One day I saw that a great many more would die and thought that the cause might be from feeding stale beef hearts. I stopped feeding for ten days and then began giving them live minnows, and in a week's time the mortality stopped and I have lost very few trout since."—Albert Rackow, Elmont, L. I.

That there are occasional epidemics among fish is a fact familiar to all who have had much experience with them, and the cause is not at all understood. In the summer of 1850 or 1851 the perch and pickerel in Kinderhook Lake, Rensselaer County, N. Y., died in great numbers and came in shore to die; some boys who had walked down to the lake from Albany with me refused to fish or touch the fish that were struggling near the shore, we believing that they had been poisoned. In 1856 I saw thousands of black bass dead upon the shores of the small lakes along the Mississippi River, near Potosi, Wisconsin. Some lakes in Central New York—Hemlock, Honeoye and Canadice Lakes—had an epidemic that killed many perch in the summer of 1870. In 1883, St. John's Lake, at Cold Spring Harbor, N. Y., had a disease which killed the sunfish in such numbers that the air was tainted. Greenwood Lake, lying partly in New York and in New Jersey, has been visited by a similar epidemic, although I cannot give the years.

To further prove that these things are beyond the knowledge and control of man, and also to show that they are not confined to fresh water, I will cite: Within ten years, more or less, the United States Fish Commission discovered a new and valuable food fish by methods not pursued by the commercial fishermen on the New England coast. The fish had no common name, of course, and as the scientists had christened it by the pretty and simple name of *Lopholatilus chamæleonticeps*, and as it was evident that the marketman and the club steward might not grasp the full meaning of all the syllables, the last one in its front name was shortened and it bloomed upon the market as the "tile fish."

It had hardly got in favor with the New York and Boston hotels when reports from ship captains came in that they had sailed through miles of strange fish floating dead upon the water. This was about 1884, and not a single fish of this species was taken until 1898. It was believed that they had been exterminated by some submarine disturbances, but our later reports show that enough escaped the catastrophe to perpetuate the species. It is a valuable food fish, but one which, by its deep water habitat, escaped our fishermen until the Fish Commission found it by fishing beyond the banks, where the hardy cod fishers do not go. It is now increasing in numbers.

Cases of mortality among fishes might be extended, it being well known that in Lake Ontario some of the smaller "lake herring" die off yearly in great numbers, a fact about which we have nothing to base an opinion.

The following is from a recent New York paper:

"Port Jervis, N. Y., May 18, 1898.—The shores of Monhagen and Highland lakes, near Middletown, are

lined with thousands of fish, mostly dead catfish. Men have been engaged for three days in removing them, but are making no headway. As they clear a patch, it is covered again with dead fish washed to shore. Hundreds of wagon loads have been removed in this manner. The bass with which the lakes were stocked a few years ago do not appear to be affected. A similar phenomenon was experienced in Green's Basin, north of here, a few weeks ago. No explanation of the occurrence can be had."

Summing all this up, there seems to be no way of preventing disease, whether sporadic or epidemic, among fish, except to keep the ponds clean if they are densely populated and to treat cases of fungus with salt water, where possible, and to remove every infected fish at once.

Most other diseases of trout in ponds, such as blindness, the turning in of the flap of the gill cover, where it grows fast, exposing the gill, are not common enough to warrant seeking a remedy. In blindness there is no hope for improvement, and as a gill cover once turned in and grown fast refuses to be straightened out, it may be well to let it be as it is.*

CHAPTER XXXVI.

ENEMIES.

As it would require a volume to tell of the enemies of salt-water fishes—which, by the way, are mostly other species of fish, and the marine mammals—this chapter

* See chapter xliii on the working, or blooming, of ponds.

will merely glance at such forms of life as prey on the fish of rivers, lakes and streams.

FISH.

Large trout are usually cannibals, and in private ponds should not be allowed to live. I have seen a trout try to swallow one that was so near its own size that it could not pouch it and it swam about all day with a portion of the tail and caudal fin—they are not the same—protruding from its jaws. Such fellows I always netted out, or speared, for once they begin the habit they never stop it, and they will devour many times their own weight in a month.

A small fish known as miller's thumb, blob, muffle jaw, and star-gazer, belonging to the genus *Cottus,* or *Uranidea,* for they shift the names occasionally, is called bullhead in England. It is a homely, big-headed little thing, and Jordan records nine species, from three to five inches long, one species reaching seven inches. They are found in the Great Lakes, rivers and streams from Lake Superior to Georgia. They lie on the bottom or under stones and move after the manner of the darters. This fresh-water sculpin is one of the natural checks on the overproduction of trout and salmon. It eats the eggs and the young fish. It is found in all trout waters as far as examined. It is very destructive. At an experiment once made in the aquarium of the United States Fish Commission, in Washington, a miller's thumb about $4\frac{1}{2}$ inches long ate at a single meal, and all within a minute or two, twenty-two little trout, each from three-quarters of an inch to an inch in length.

Most fish will eat smaller ones, if we except the sturgeons, the whitefishes, suckers, carp and goldfish, and these will eat fish eggs. The pikes eat nothing but fish, and we have five species of them, while Europe has but one. Eels are very destructive.

REPTILES AND BATRACHIANS.

Most of these eat fish to a greater or less extent. The water-snakes, garter-snakes and the black-snake eat fish, and perhaps other species may also eat them. All the snapping turtles, pond and river turtles eat fish. The little land tortoises called "box turtles" may take insects, but will not eat fish. I have kept them for years, and their food, as far as I could observe, was vegetable. Those large salamander-like forms all eat fish. They are the "mud eel" (*Siren lacertina*), thirty-six inches, Northern Indiana to North Carolina and south; the proteus, mud puppy, water dog (*Necturus maculatus*), called "lizard" in the Detroit River, twenty-four inches, Eastern United States, chiefly north and west of the Alleghanies; this animal has its gills outside its head; I have eaten this beast. The hellbender (*Cryptobranchus alleghaniensis*), twenty-four inches, Ohio valley and south, lives largely on small fish. The ranges and lengths given are from Jordan's "Manual of the Vertebrates."

Frogs, especially the large ones, eat fish, and I once took from one a young snapping turtle, about an inch ($2\frac{1}{2}$ c.m.) in diameter. The toad frequents the water at times but does not eat fish.

The frog is popularly supposed to spend its time in summer in rendering Wagnerian operas and catching

insects, but I have taken from its maw small frogs and fish. Once, while fishing in the Adirondacks with "Jack" Sheppard, the guide, a great bullfrog plunked in the water and soon climbed the log again, swallowing something.

"That fellow's got a fish," said Jack.

"Don't believe it. His splash would scare a fish, and

HELLBENDERS (*Cryptobranchus alleghaniensis*).

he can't swim fast enough to catch a fish. Let's catch him and see."

"For the cigars at Bennett's?"

"For the cigars. He never got a fish in that short time, after that plunk."

Jack reeled in his line until it was about the length of the rod, while I slowly paddled and drifted up to the batrachian. Jack swung the fly above his nose, and he

was our frog. "Make it half a dozen cigars?" Jack asked.

"All right; make it a round dozen."

I had on a previous day remonstrated with Jack about not killing a frog before he cut it in two and skinned the legs; the sight of the living portion annoyed me, and as he was my guide I forbade the practice. He unhooked the frog and handed it to me. A blow on the head with a heavy knife-handle and a cut into the brain stopped all feeling, and then he opened his inner works, and there was a little sunfish, about two inches long.

"Jack," I remarked, "you've won; but as you were booked to win in any event, as I buy the cigars every night, you have not won much. I am the real winner, because I have learned something. Now let's not waste this fellow, but stop trouting and get frogs enough for breakfast. How did that frog catch that fish? That's what I want to know."

Jack tossed the little fish overboard and merely remarked: "It's funny how they do it, but they do."

"Jack Sheppard, I asked you a plain question that should have a straight answer, and all I get is the refrain of a music hall song. How did the frog catch that fish? Did it catch it when it made the dive from the log, or did the frog dive to the bottom and come up under the fish? That's the question."

Jack threw the skin of the legs overboard and followed it with the body of the frog, laid some fresh grass over the trout in the creel, placed the legs on the grass, looked up and remarked: "I'll be durned if I know." *

WATER SNAKES.—Few sportsmen know more about

* This and some other anecdotes in this chapter were originally written by me for *Forest and Stream*. F. M.

snakes than to have about half a dozen names to cover them all, and few men see more snakes than the men who fish and shoot, yet Jordan ("Manual of the Vertebrates") gives us twenty-four genera and fifty-three species in the northern United States. Of these there are four which haunt marshy places and feed mainly on fish and frogs, although none of them would neglect a bird if it offered, whether the bird was nesting on the ground or feeding. And the other species may also take fish, for all I know, while it is sure that none of them would decline a frog.

These four piscivorous serpents have come frequently under my notice at times when I have been fishing alone from a boat or a log as a "contemplative angler." That is the way to see not only snakes, but other life, and I have fished with the four fish eaters and have seen them fish. I do not kill all snakes; in fact, I love to pet the "puff-adder," or "hog-nosed viper," for it is kind and likes petting; it is not poisonous, as the majority say it is, but it flattens its head and threatens, then I pick it up and we are friends. But the "four," the "big four," and we might add, "the dirty four," I kill them on sight. Two of them are as poisonous as the rattlesnake, and the others are vile beasts.

The common water snake of the North (*Tropidonotus sipedon*) grows to a length of four feet. It is of a dirty brown color, with darker squares. It ranges from Maine to Texas, and is found along the streams, a cross, disagreeable reptile. From 1868 to 1876 I had trout ponds at Honeoye Falls, Monroe county, N. Y., and this snake was a pest. The soil was a stiff clay, and a crawfish hole would never cave in, but made a good place for *Tropidonotus sipedon* to hide in. On approach-

ing the ponds in summer there would be many of these snakes seen to dodge into the water and hide under the overhanging grass. It was fun to see lady visitors screech when I threw off my coat and plunged the left arm under the bank, bringing out the angry beast, which, if not taken too near the neck, vented its wrath in sinking its teeth into my hand. But it was only like a brier scratch; not half as severe afterward as the prick from the spine of a catfish, but when my good right hand took the reptile by the head and twisted it from its body, some people thought it cruel. To me it was "cruel" to see a snake take a trout, especially one that I had raised. Yet that snake filled its place in nature; the main trouble is that man writes up all these things from his point of view, just as I am doing.

The other non-poisonous water snake which I know, although others are recorded, is the Southern one (*T. fasciatus*), which has dark vertical bands on its sides, and has a reddish-brown belly. This snake is seldom found north of Georgia. I knew it quite well, having looked it over for poison fangs and found it to be harmless, so when a lady from Ponchitoula landed one and was about to spring out of the boat, I called to her to swing it over to me. She did so, and I was tempted to bite the animal's head off, just for bravado, but merely unhooked it and killed it with my heel.

The Northern sportsmen should remember this: Our North American poisonous serpents have triangular heads and also have a deep pit between the eye and the nostril, like a second nostril. The snake known as a copperhead in the North and cottonmouth in the South (*Ancistrodon contortrix*) has the top of its head a coppery-red, and a lot of V-shaped blotches on its back. If I am not mistaken, it is called "pilot" and "rattle-

snake's mate" in Pennsylvania. It is very poisonous, but is not as common as it was. While fishing for black bass in the Delaware River, one crawled out of the water with a perch in its mouth so near me that I killed it with a stone.

From Illinois south dwells the water moccasin (*A. piscivorus*), said by Jordan to be the most dangerous of our snakes. I have seen them hanging on bushes over the water ready for fish or frog, and have killed several that had fish in them. When fishing in Southern waters I keep a good lookout for these animals, which give no warning rattle, but carry small doses of sudden death ready to be injected into the leg of a peaceful angler.

Tortoises and Turtles.—In America we popularly call them all "turtles," and the distinction of "tortoise" for the land and fresh-water kind is almost unknown, while the principal exception is that delicate box of gelatinous meat, the diamond-back terrapin of the salt-water marshes. I never knew the box tortoise to eat fish, and I have had them in captivity for years; they seemed fond of fruits, melons and tomatoes.

All the pond and river turtles are great fish eaters. They will float up quietly under a fish and make a grab for it. Some years ago I was using a live minnow for black bass, on Long Island, when I saw a great snapping turtle take the minnow and go below. A few pulls showed that a trout rod would never stir a thirty-pound turtle from the mud and weeds, and I kept weaving the rod from side to side in order to cut the snell on the reptile's jaw, in order not to lose the entire leader. The game worked, and a hook was the only loss. I have taken these brutes on night lines set for eels, but there were hooks selected for that work, and no gut snells.

The large, soft-shelled turtles of the Great Lake region and the South are also savage fellows. A young man who was fishing near me in the Pamunky River, and using strong tackle, pulled in one of these critters and held it up to show me. Soon he yelled for help, and I rowed over to him and found the turtle fast to his shoe and biting his foot. He was in too much agony to help himself, and I did not know what to do. The first impulse was to seize the long neck and shut off the turtle's wind; as I did this I realized that it could do without breathing for an hour or two, and all the while the man was in agony with the cruel beak forcing itself through the thin upper of his shoe and into his foot. On the seat beyond him lay one of those strong dirk-knives which are sold to would-be sportsmen as "hunting knives." Fortunately it was sharp, as well as strong, and the way I vivisected the lower jaw out of that turtle took all my strength, and would have won applause from the cruelty society. The young man fainted at the finish, but a little water and fanning brought him around. When his shoe was removed there was much blood in it, and on taking off his stocking I found that the little toe was nearly severed, and the next one was injured. I bound up his foot in his handkerchief and towed his boat to White House landing, where he had friends. He lost one toe, however. He said that the turtle had swallowed the hook, and he had cut the line to let him have it, when the turtle began running around to escape, and he kicked at it. "Well," said I, "you keep that hunting knife as a reminder, not only of the loss of your toe, but as the first instance known where such a knife was found to be useful."

Passing from turtles, which are truly dangerous,

down to the little "skillypots" which sun themselves on logs, is like descending from tiger hunting to shooting rabbits. The turtles before mentioned never sun themselves on logs. They may float on the water a few minutes when they come up for air, but they remain in the water at all times, except when eggs are to be laid on land for the sun to hatch. Here is a grand division not noticed in the books. From the big "sliders" of the South to the painted and spotted pond turtles of the North, they are all fish eaters.

Birds.—All ducks eat some small fish occasionally, and some birds live almost exclusively upon them. These are the grebes, helldivers, loons, gannets, pelicans, cormorants, the mergensers or sheldrakes, herons (often miscalled "cranes"), bald eagle, osprey or "fish-hawk," and kingfisher. The gulls eat fish, or any other thing that comes handy, but as they are not divers it is only the dead or injured fish that come to the surface which they can get.

The Kingfisher.—This jolly bird is common everywhere, whether up some little trout stream, which the angler has just discovered, but which the kingfisher knew years before, or along the rocks and beaches of old ocean, where it seeks its prey among the breakers. There is no bit of fresh or salt water on this continent that the kingfisher does not frequent and where its cheery whir, like the song of the reel, is not heard. Every youthful angler saw one on his first fishing trip, and also learned its name, which fortunately is the same from Florida to Alaska. The Germans call it the icebird (*Eisvogel*), and the name seems inappropriate, although it often remains all winter along the northern coast, near open waters.

Once I cast a minnow for black bass, and some fish

struck at it and knocked the bait on top of a lily pad. A passing kingfisher saw it, stopped, hovered and dove. The bird struck the water hard just as the minnow floundered into it, and bore the fish some feet in the air until it learned that its prey was fast to something, when the bird dropped the fish and alighted on a dead limb and scolded away. In fact it always scolds when it misses, and I have been in doubt whether it can spring its rattle with a fish in its bill. By the marks on this minnow the long bill of the bird did not pierce it, but it struck the fish about the middle, leaving a mark on each side.

The kingfisher sizes up its prey and does not take a fish which it cannot swallow whole. It takes the fish head first, after it has seized it crosswise and gone to a limb to swallow it. This I have learned by dissection, for as a fishculturist I was forced to protect my trout fry from a bird which has always been a welcome companion on angling trips.

The kingfishers nest in holes in the bank, usually under the protecting roots of trees, and the young seem to be able to reject fish bones, or to pass them undigested, I don't know which. Nor do I know how the young are fed, whether as pigeons are fed, or whether the old takes a fish to the nest and picks it to pieces for the fledglings. In fact, there are many things which we may never know of the life history of wild birds, because we cannot be allowed to intrude upon their privacy.

The Osprey.—This is a large bird of the great family of falcons, which includes the eagles, hawks and kites. Osprey is the correct name of the bird, which is called "fish-hawk" in many parts of our country, and not without reason. It ranges almost over the world,

and is not confined to America. This fact, in combination with the other fact that the name "osprey" is more universal than "fish-hawk," leads me to use the name which is wider known, even if not so descriptive.

Did you ever watch a kingfisher hover at fifty feet, dive and strike its prey; or an osprey do the same thing to a larger fish at three times the distance? If you have done this, and have seen these birds take their fish in from one to three feet of water, you may have wondered at it in an indolent sort of way, and have gone on fishing.

Stop here and think! Put your hand a foot above the water and try to grab a fish that is just below the surface and you will fail. Then consider what the kingfisher and the osprey do at the heights at which they dive, and make a good living at it, and you will marvel how the birds do it with repeated success, while you can never catch even a little minnow in your hand.

The osprey can sail in circles, like all of its class, but it often flies in a direct line, with head bent down to scan the waters below. When it sees a fish of the desired size or kind, it hovers, as the kingfisher does, and then like an arrow it dives, and rarely misses. Unlike the kingfisher, it emerges from the water with the fish in its powerful talons, and not in its bill, and then wings its way into the woods to feast, or to feed its young.

A PLANT.

A water plant called "bladderwort" has a reputation for capturing small fish and feeding on them, as the pitcher plants feed on insects which venture into their parlors after the sweet juices held there. I had read

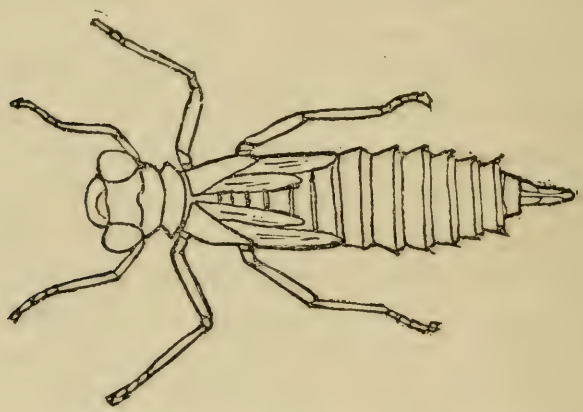
something of this plant in the report of the United States Fish Commission for 1884-5, but did not know it. Late in July, 1889, I was ordered by Mr. E. G. Blackford, President of the New York Fish Commission, to make an examination of the two principal lakes of Long Island, at Ronkonkoma and Riverhead, and Dr. Bashford, Dean of Columbia University, volunteered to assist, I to work up fishes and crustaceans, and he to do the same for plants and insects. A full report of our work may be found in the report of the State Commission for 1889.

When Dr. Dean showed me the plant it was well known by sight, but the idea of those little bladders, one-sixteenth of an inch long, destroying a fish seemed absurd. Dr. Dean did not have to go far to study the plant. Three varieties—the *Utricularia vulgaris*, *Pinior* and *Purpurea*—were found in the Long Island ponds in quantity and under natural conditions. The plant is found in rope-like masses growing from a big round bud. It is more or less floating, and dies at one end as it grows at the other. In the winter the stem dies up to the terminal bud. It blooms in June in Long Island waters, its yellow clusters of flowers reaching up above the surface of the water. The leaves are delicate and fringe the stem. From their axils arise the bladders. From its small size I am skeptical about its taking any fish.

INSECTS AND THEIR LARVÆ.

While furnishing food for trout, as well as other fishes, there are some species of insects which turn the tables and kill the trout. A flat beetle (*Belostoma grandis*) grows to a length of two inches, and will attack a

yearling trout. It has swimming legs behind, powerful forelegs, a boat-shaped body and a sharp proboscis; the larva of this beetle is a green worm the size of a lead pencil and nearly three inches long. Always kill these things. The margined beetle (*Dytiscus*) has hard shards covering the wings, strong swimming legs, and a pair of pincers in front; length of body one and one-half inches; female with fluted shards and male with smooth shell-like back, around which runs a yellowish-white stripe; the larva is the "water-scorpion," a round-bodied larva, with light rings at each abdominal joint.

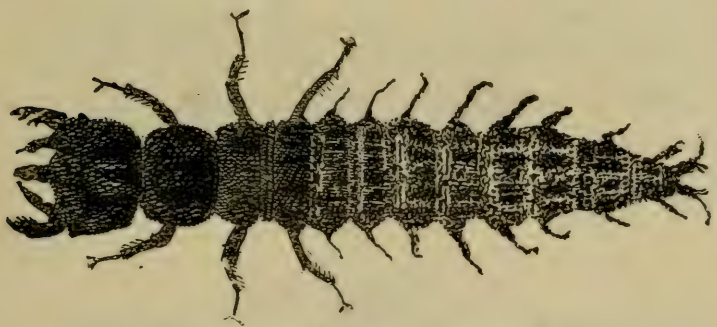


PUPA OF DRAGON FLY (natural size).

The larva and pupa of the dragon-fly are very destructive to small fish. Few insect pupa take food, but this animal feeds all the time; it has a pair of pincers on an extension arrangement, which is hinged to the front part of its head; there is a middle joint to this which lets the pincers lie in front when in repose, but allows them to be thrust out nearly three-fourths of an inch when it seizes a fish. I once put six young gold-fish, three-quarters of an inch in length, in a bowl with a dragon-fly larva, and it killed all six fish inside of an

hour. This dragon-fly (*Libellulidæ*) is also called darning needle, mosquito-hawk and demoiselle. Perhaps the adult insect has its uses, but the fishculturist has no use for it.

The great larva of the helgramite fly (*Corydalus cornutus*) may kill some fish, but if it does I don't know it. This larva is two and one-half inches long, and has a powerful pair of pincers; it lives in brooks, under stones, and crawls ashore to enter the pupa stage under logs. The great insects fly by night and are seldom seen; the larva is a famous bait for black bass, and is called dobson, crawler, kill-devil, and about twenty

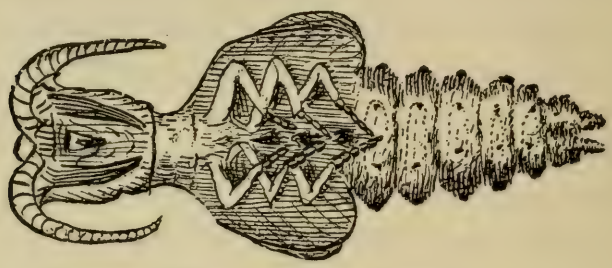


HELGRAMITE LARVA, "DOBSON."

other names. The female fly has short pincers, like the larva, but the male has two long "horns," which cross at the tips.

The little "water boatman," which rows himself along, cannot harm fish to any extent. Trout will not eat them, nor will they touch "whirligigs," which play in schools on the surface; nor will they taste of the water cricket, "skater," or "skeeter," as it is variously called—the little, dried-up fellow which stands on the water with only its feet touching it. These water crickets eat small insects, but seem to get no good

from them, for they appear to be as dry inside as they are outside. If the "whirligigs" eat anything it is when I am not looking, for they are so occupied with their game of tag through a crowd of their fellows that they



PUPA OF HELGRAMITE.

cannot spare time to feed, and it is hard to tell who is "it."

The larva of the stone-fly is the caddis, which makes itself a case of leaves, sticks, sand, or other material, and is harmless in all stages; therefore it has no busi-

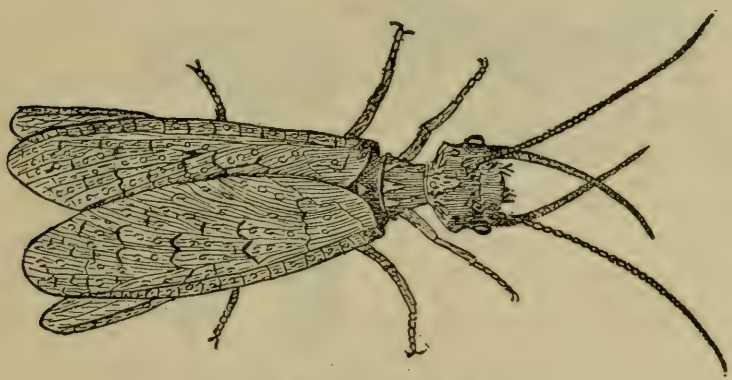
FEMALE HELGRAMITE FLY.

ness to be included in the chapter on enemies of fish; but insects will not get another inning in this book, and the fishculturist might wonder what the larva might be. Another good fish food that cannot harm a

fish is the soft larva of the May-fly, also called shad-fly, eel-fly, and by other names; it is one of the ephemera which only lives for a day or two in the perfect, or imago, state, but passes several years in the larval state in the water.

MAMMALS.

Years ago I met in executive session, all alone, and passed a law that I should not be allowed to take the

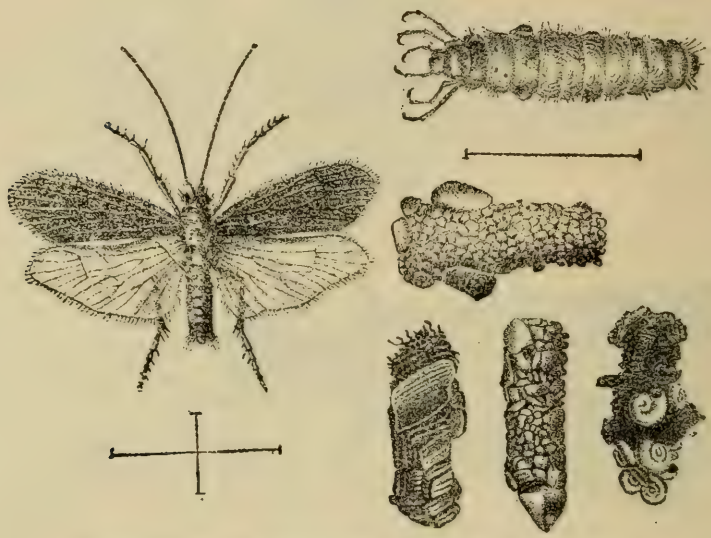


MALE HELGRAMITE FLY.

life of any living thing unless it was needed by me, or because it worked injury to my interests. Those are the only circumstances under which a man should kill anything. The law was flexible enough to allow of shooting a few game birds for my own table and for taking fish also. A pair of ospreys, sometimes called "fish-hawks," nested above my ponds every year, and often sailed over them with longing eyes, but my orders were not to harm them; they went to the salt water a few hundred yards below, and it was worth the price of admission to see them plunge from a height of a hundred feet and get a fish. One young one, and only

one, had to be killed because he would not be "shooed" nor stoned away from the trout ponds.

This is related to show my forbearance toward the muskrat. In summer musky would come into the inclosure and swim about a big pool below the ponds,



STONE FLY (*Phryganea*), LARVA AND CASES.

raise a brood and enjoy life. When he burrowed into the dams he was trapped, and I often said to him before the yelping terriers had a whack at him: "Now, Musky, if you and your tribe will only dig where I want digging done we will dwell in peace; but you persist in boring into my dams, and we are no longer friends." But the terriers had no argument to make.

MUSKRATS.—For years I had suspected the musquash of eating fish, but had no evidence. The ground for suspicion was that the muskrat ate animal food in the shape of fresh-water mussels (*Unios*), as was shown by the piles of shells which he took the trouble to carry to a favorite place. He is a queer fellow, and his habits are worth

studying; he leaves his "sign" on a stone or log, in a conspicuous place, and never buries it, as dogs and cats do. I gave musky the benefit of the doubt, knowing that he is the nearest relative of the beaver, and the name of "musk beaver" would fit him better than the one he bears. Having dissected hundreds and found no remains of fish, I was still skeptical, because of the eating of *Unios*.

With all this in mind, I decided to find out what others might know on the subject, and to do this there is no way in which one can reach such a body of observant field naturalists as in the columns of "Forest and Stream." Therefore I wrote:

"In 'Forest and Stream' of July 30, 1898, I said that I had always suspected the muskrat of eating fish in the winter, because it is well known that it eats animal food in the shape of *Unios*, or fresh-water mussels, but most of these rodents that I had examined were killed in summer, when they were mainly feeding on vegetation. I asked: 'Can any one prove that the muskrat eats fish in winter when vegetation is scant?' To this question there came but one reply, but it was so full and complete that I publish it as a contribution to the life history of the muskrat. No doubt thousands of men have known for years what Mr. Held writes, but as I did not know it, and I have known the musquash as boy and man for over half a century, and as a summer burrower in my trout ponds for at least half that time, it is fair to assume that others may not know about the fish-eating habits of the muskrat.

"Here is just the kind of letter that I love to receive. It is from Mr. William C. Held, Saginaw, Mich., and says:

" 'You ask if any one can prove that the muskrat

eats fish in winter. All our net fishermen can prove that they eat fish, as they are the most destructive thing they have to deal with during the fall and winter months. They chew into the nets and then chew out again, and in this way they let out many fish before the holes are located and repaired. As soon as the fishermen have their nets set in the fall, they commence trapping around them, and in this way they catch most of the rats; but there are always a few that remain uncaught, which cause trouble all winter.

" 'In the winter one can see places on the ice where the muskrats have carried fish and eaten them night after night. Last spring I saw a fish-box into which a muskrat had gnawed a hole for the purpose of getting at the fish.' "

The Mink varies his diet of poultry and game with fish. Once I dug out a mink's nest, and found a great lot of feathers, bones of birds and of fish, all around the helpless young. The mother escaped by another hole, and as for the old male mink, he would only take interest enough in the family to kill the young; and that is one good trait in the mink, as cruel and bloodthirsty an animal as walks this planet—one who kills for the love of killing, and is almost as bad as the human game hog who kills for count and brag.

Otters are fish-eaters, and eat little else, but the American fishculturist has no fear of them, for they are entirely exterminated in parts that are only sparsely settled; yet in Germany they are a pest to the fishculturist, and in that densely-populated land, yclept "Merrie England," packs of other hounds are still kept up.

The Bear visits the streams where suckers run up to spawn in spring, and he impales them on his claws, or scoops them on land, and possibly may agree with a

noted thief and confidence-man of New York, who said: "A sucker is born every minute."

Domestic Cats love fish, not in a platonic sense, but as epicures; and as much as they dislike to be wet, I have known a cat to plunge into a stream for fish. We all know that the house cat will wet a paw in the glass globe for a goldfish as readily as she will go for the canary bird when no one is watching, but few know that tabby will dive for fish. While fishing for trout between the mill ponds at Cold Spring Harbor, Long Island, and leisurely casting in a pool, a splash drew attention to a large cat just emerging from the water with a handsome trout. She was wet all over, and must have struck her game where the water covered her back. I had neither gun nor pistol, and pussy lived to report. When I have a gun I make it a point to kill every cat that I find in the woods. My love of robins and other birds has brought me to hate this domestic tiger, which kills them. A maiden lady in the village usually had from twenty to thirty cats, and although she fed them well there was no brook trout on their menu. Near her father's stables there was a private trout stream, and the owner gave me the privilege of taking eggs for the State. My men reported that every morning there were remains of trout on the bank, where cats had eaten them. I rigged a dozen steel traps in places where cat tracks hinted that they would do the most good, and said nothing to my men, for they had relatives near. Knowing the racket a cat in a trap would make, I was there before daylight in order that there should be no disturbance of my neighbor's sleep. Three cats were my only reward, and as that didn't pay the scheme was dropped.

The Raccoon.—This very scientific fisher has been

left for the last, but it is not least. The Germans call this animal the "wash bear," from its habit of washing things before it eats them. As the coon is omnivorous it may be questioned if it washes birds; and I know that it does not wash green corn, the "roastin' ear" of the South. The old darkey song says:

"Ole Mistah Coon's a mighty man,
He carry a bushy tail;
He steal ole massa's cawn at night,
An' he husks it awn de rail.

"De squirrel hab a bushy tail,
An' stumpy grows de hair;
De ole coon's tail am ringed all 'roun',
An' de possum's tail am bare."

Here is a condensed natural history, and such simple songs made negro minstrelsy popular forty years ago, but what they sing to-day is characterless.

Next to the fox, if not before it, the coon ranks in cuteness. I saw one wade in on a riffle and go up stream, turning a stone with one forepaw and grabbing any fish or crayfish which might dart out with the other. It was in the summer, when the streams were low in Louisiana, and I had been fishing, but at that time was sitting on a log taking a bite at noon. A bunch willow concealed all but my head, and when the coon came in sight I suspended mastication and tried to suppress breathing, for a fellow may be out for years and not get a chance to see a wild animal search for its food as if it was unobserved. There was no desire to kill the coon, for it was midsummer, and neither flesh nor skin were good; and then I'm that sort of fellow that, when not pressed for meat, would spend half a day to see a chipmunk dig its hole, and think the time well spent.

The coon proceeded cautiously, with one paw ready to grab before a stone was disturbed; then the stone was quickly upset and a grab made, and a crayfish was captured; just how I could not see, but in a way that avoided the two great pinching claws, which were then broken off, and the crustacean scrubbed and eaten, as some darkies eat peanuts, shells and all. This accounted for the number of these claws seen on the riffles. I wonder if all coons break off the claws from crayfishes before they wash and eat then.

Coons also kill and eat the small pond turtles, the painted and spotted ones of the northeastern United States, and perhaps the larger "sliders" of the South. I have never seen them eat a turtle, but have seen the empty shells picked quite clean along the shore, and usually surrounded by coon tracks, forming good circumstantial evidence.

While fishing in Kansas a coon came out of the woods and washed a frog within thirty feet of me, and scrubbed it well, and went back into the brush.

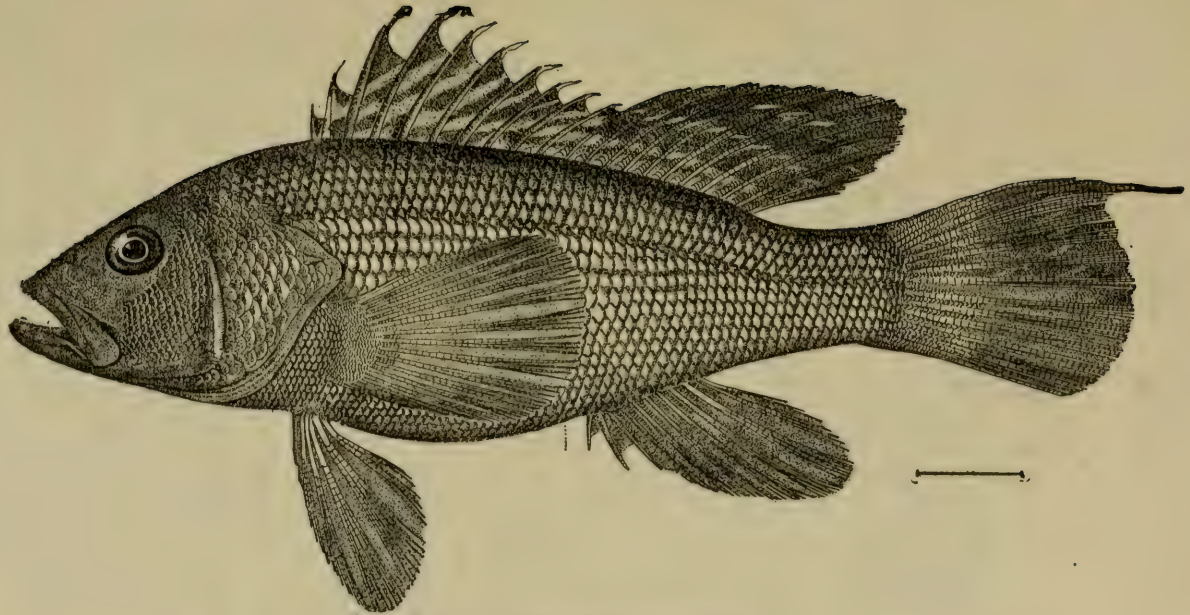
"Oh, Mistah Coon's a cunnin' t'ing,
He ramble in de dark;
An' de only t'ing dat 'sturbs his mind
Is to hear ole Ringo bark."

SECTION VII.

SALT-WATER FISH.

Many salt-water fishes have been successfully hatched, but never for rearing in ponds. The work has been confined to the United States Fish Commission, and the States of New York and Massachusetts. The first work of the kind in America, as far as I know, was done by me at Noank, Conn., in June, 1874, when Prof. Baird wished to try and take the eggs of some sea-bass (*Centropristes striatus*), which were confined in fish cars. This was done with bleeding hands before I learned just how sharp these fin-rays were. I used floating boxes, and took many eggs, which were quite small, being twenty-five to the linear inch. These eggs were watched under the microscope several times a day, for the scientists of the United States Fish Commission were there, and the development recorded. Things went well until the fourth day, when a storm upset the boxes as the eggs were about to hatch. (See Report U. S. F. C., 1874.)

Since that the experts have hatched the scup, or porgy; the tautog, or blackfish; the flounder, sea herring, sheepshead; weakfish, or squeteague; cod, haddock, Spanish mackerel, and other salt-water species.



SEA BASS (*Centropristes striatus*).

CHAPTER XXXVII.

CODFISH.

The cod family is the most important of all the fishes, containing a large number of species of considerable size, distributed throughout all the parts of the northern hemisphere in great numbers. The cod is easily captured and readily preserved. It feeds more men than any other fish. Norway lives from it, and exports 60 per cent. of the catch.

It was the fisheries and not the sterile rocks of Massachusetts which tempted our ancestors to settle on that rock-bound and inhospitable coast, and their descendants remembered this when they put the great gilt codfish in the State Capitol, where it hangs to-day, to remind the law-makers that once the "Codfish Aristocracy" was the real thing, for the very existence of our "first families" in the early emigration days depended upon the humble codfish.

The nutritious cod is found in the North Atlantic, North Pacific and Polar oceans to far beyond the Arctic Circle. In the West Atlantic it occurs in winter in considerable numbers as far south as the mouth of Chesapeake Bay, latitude 37 degrees, and stragglers have been observed off Cape Charles; Cape Hatteras may be considered its southern limit.

Its distribution on the Pacific coast is not so well known, although it appears to occur on all the off-shore banks of that coast and to the coasts north of the Straits of Fuca.

There is a cod bank outside of the mouth of the Columbia River, but it is not much fished, and on the

Pacific coast, the cod fisheries of Alaska are of the greatest importance; but the Pacific fisheries are increasing.

The cod spawns all winter, from November to the last of March. Its eggs are free, and will float in water of a density of 1.026 for a week or more, when they settle down a little. At a temperature of 45 to 38 degrees they will hatch in from two to three weeks, and absorb the sac in a little less than half that time. The Government hatcheries at Gloucester, since 1878, Wood's Hole and Ten-pound Island, Mass., turn out great numbers, but we never made much of a success of it on Long Island, mainly because the water was seldom denser in the inner harbor than 1.018, and of the difficulty of getting and transporting the eggs.

Many a cold morning before sunrise have I and my men been on the fish cars at Fulton Market taking cod eggs with fingers which had no feeling in them. Then we would take the eggs in jars of water and on flannel trays to be taken to the hatchery. I once took 3,000,000 eggs from a twenty-five-pound cod, and left some which were not matured. A cod is sexually mature at four years old. When spawning at sea the sexes do not seem to come close together, as is the case with most of the fishes with whose spawning habits I am familiar. If the egg meets the milt of the male and absorbs a spermatozoon, while absorbing water, the egg is fertilized. But nature, which gives the trout a few hundred eggs, provides the cod with millions, to cover their loss by not being fertilized, and many are thrown on shore.

Special apparatus was needed for floating eggs, and the late Capt. Chester devised a "tidal hatcher" that let the water in at the bottom and out by a siphon,

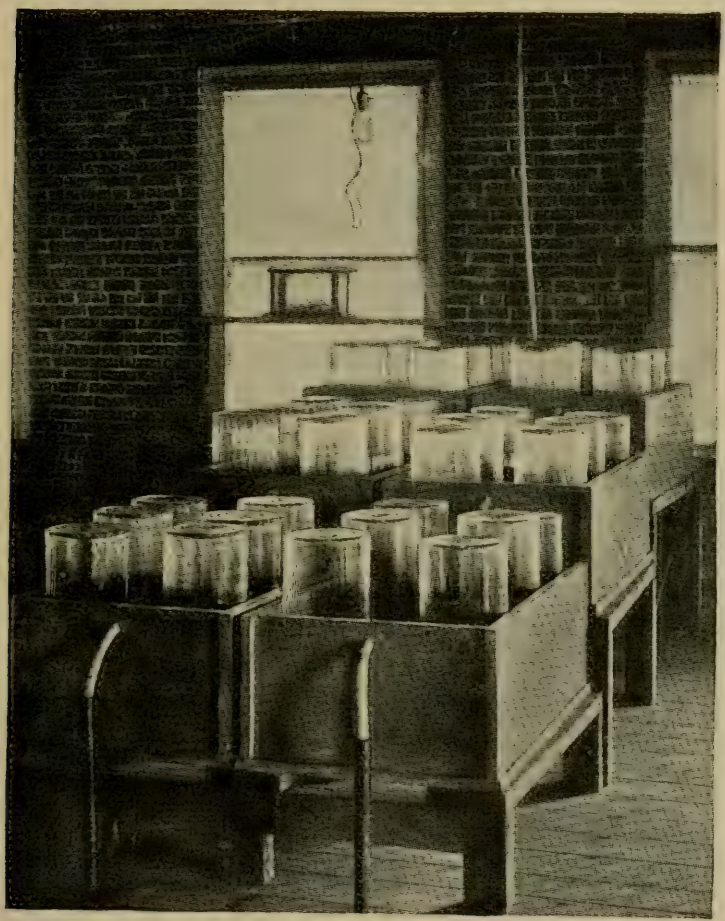
which caused the water to rise and fall in the jars. These jars had holes in their bottoms, which were corked, and the jars filled with eggs and water; a bit of cheesecloth was fastened over the top, the jars reversed in the box, on strips, and the cork removed. The water would then rise until the siphon began to work, and then it would fall until the siphon stopped.

CHAPTER XXXVIII.

THE TOMCOD.

This fish (*Microgadus tomcod*) is a miniature codfish, to the casual observer; rigged out with three dorsal fins and two anal fins in true cod style. It ranges from Labrador to Virginia, coming into harbors to spawn in brackish water. In some parts it is called "frostfish," but there is another fish by that name, and "tomcod" is more generally used. In New York harbors it spawns along the docks and in the weeds in December; eggs free and heavy, about fifteen to the inch. They hatch in thirty to forty days, and the young take food at four to six days, according to temperature. The tomcod grows to two pounds weight, but the average is between one-quarter and one-half pound. I began hatching this fish in 1884, with some sneering from the inland Commissioners, but when those who live near the salt water found it out the applications for them came in fast. The fish increased in all the harbors. In my report to the New York Commission for 1893, page 36, I say: "Between November 27 and January 15 we had a good run,

and turned out nearly 16,000,000 fry, which kept our salt-water pump going day and night. This fish is very prolific, as is shown by the fact that from thirty-two females we got an average of 30,000 eggs each, and we



CHESTER'S TIDAL HATCHER.

have taken as high as 75,000 eggs from one female. Larger tomcods and more of them were never seen in this harbor before."

If the eggs are placed in fresh water from the start

they will hatch, and I have reared them in fresh water; but if the salt water failed and we changed to fresh after several days, the fish often hatched, but died. This would be a good fish for large lakes, because it has soft fins, and is therefore better food for big trout than any sharp-finned fishes.

CHAPTER XXXIX.

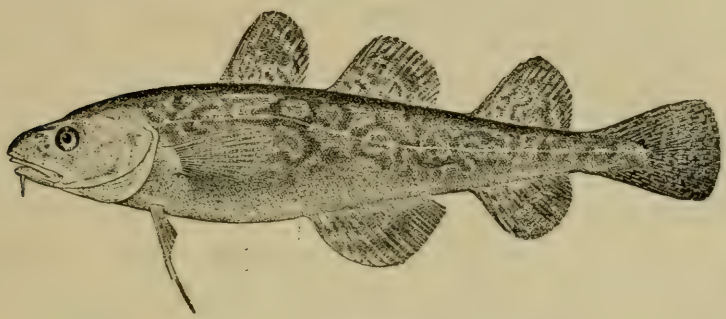
LOBSTERS (*Homarus*).

In the latter part of the winter of 1885-86 the late Prof. Baird caused experiments to be made at Wood's Hole, Mass., with lobster eggs. At that time it was the belief that lobsters spawned all the year round, because eggs were found on some females at all seasons. We now know that an individual spawns but once in two years. She can only grow when she sheds her shell, which she does not do while eggs are attached to her abdomen. This is the routine: Say she has shed and spawned in the late summer of 1890; the eggs hatch in the summer of '91, after which she makes growth and moults, not spawning again until the next summer.

LOBSTERS ARE BIENNIAL SPAWNERS.

In the "Scientific American Supplement," No. 945, February 10, 1894, was published an article of mine, entitled, "What We Know of the Lobster," which that paper had held unpublished since September, 1892, sixteen months, as is shown by the letter of Prof. Samuel Garman, given below. In the meantime Dr. Francis H.

Herrick announced his discovery that the lobster was a biennial spawner in his extensive and most complete life-history of the lobster which has ever been published; thus anticipating Prof. Garman and myself, who were studying on the same lines. In the Report of the



TOMCOD.

New York Fish Commission (1892), pages 50-57, I refer to this, and give Prof. Garman's report on the lobster to the Massachusetts Fish Commission (December, 1891). The United States Fish Commission Bulletin for 1893, pages 281-286, printed my article from the "Scientific American Supplement" in full. I can only quote a few extracts:

"The female spawns but once in two years. Notes made on the eggs of lobsters in the New York Aquarium in 1876-78 show that they hatched before July, or when the water reached a temperature of *about* 60 degrees Fahr. In 1891 I began the hatching of lobsters for the New York State Fishery Commission, and found that eggs taken from lobsters from the middle to the last of July did not hatch that year. Then it seemed as if the lobster might be a biennial spawner, but I did not dare to say so. A report of my observations sent to Prof. Samuel Garman, of the Museum of Comparative

Zoology, Cambridge, Mass., brought a letter dated August 30, 1892, complimenting my studies on the life-history of the lobster and inclosing a report to the Massachusetts Fish Commission, dated December 17, 1891, in which he shows that his investigations proved that the lobster spawned but once in two years. Therefore, I have solid backing in making the statement that heads this paragraph.

"Since this I have taken, for the New York Fishery Commission, a large number of lobster eggs, and have turned out this year from Cold Spring Harbor, Long Island, 177,000 young lobsters into the waters of Long Island Sound. These were from eggs which otherwise would have been sent to market with the parent and have been boiled and thrown away with the shells, and were therefore just so many saved from destruction and given a chance to struggle for life. There is no law in the State of New York relating to "berried" lobsters. The eggs number fifteen to the linear inch, and measure 6,090 to the fluid ounce, are attached not only to the swimmerets, but also to each other by threads, and are aerated by an almost constant motion of the appendages, and in confinement many eggs are loosened and fall off, perhaps from the habit that the parent has of poking among them with her legs. * * *

"The young do not hatch until the water reaches a temperature of about 60 degrees Fahr., which in Long Island Sound might occur after the latter part of May, and in that region the hatching season is over by the middle of July, and as the mother has been feeding while carrying her eggs, she can then shed her shell and begin to develop the so-called "coral" that epicures prize, which will form the eggs to be laid the second year. The fact that female lobsters bearing eggs out-

side, while others have the coral inside, are taken in winter, supports the theory of biennial spawning. August 16, 1893, I took a lobster from a car, which the owner told me had spawned two days before. The microscope could detect nothing in the eggs, because the yolk filled them entirely. Four days later the yolk had shrunken and the "mulberry" stage could be seen in the clear space, and by the 25th the eye was visible. The eggs are dark when first laid, and grow lighter in color as they develop. From this until October no change was seen."

The pump broke and they died.

There is no food for a larval lobster known to me that is as acceptable as another larval lobster that has just molted. I have tried to bribe them by hanging flesh of eel, clam, beef, lobster (adult), blue crab, and fiddler crab, but without avail; their love for their fellows which prompted them to take their brethren in out of the wet, lest they might be devoured by small fishes, baffled my efforts, and there was no resource but to plant the fry as soon as hatched. If each youngster could be placed in a tank, or even a small compartment, by itself, no doubt it would accept any, or all, of the foods named, but at present we are not prepared to feed a million or more individual lobsters in separate stalls for months before turning them out to shift for themselves. They cannot be reclaimed from cannibalism by any known means. They are fighters by nature, and when a lobsterman has a lot of adults in a floating car and a storm comes up each lobster blames his neighbor for any collision that may ensue, and they engage in a general fight, which is not only disastrous to themselves, but to the lobsterman, for lobsters are not marketable in fragments.

Just how the eggs are impregnated is not known. It is said that the milt is placed near the oviduct some time before the extrusion of the eggs, and that they are fertilized by passing over it. Of this I know nothing, and merely insert this paragraph to show that this question was not overlooked. The sexes of lobsters can easily be distinguished without the presence of eggs. When the pairing takes place and how it is performed no man knows. A study of the reproductive organs has developed a theory, and there we stop.

The increase of population has naturally increased the consumption of lobsters, and the great decrease in the size of this crustacean is an evidence that they are slow of growth, and the marketable lobster of to-day, weighing from one to two pounds, may be from four to six years old, possibly more. In all these estimates of weights a fairly plump, well-fed lobster is meant, and not one that would be rejected by the housewife as not worth picking the meat from, for she has learned to weigh them in her hand, and of several of the same size, to choose the heaviest.

They are hatched in jars, and swim at once. They are in a larval state at first, and moult three times before they are perfect and get the big claws. It is when it moults, and is soft, that his fellows devour him. In a natural state the youthful *Homarus* would seek shelter for this operation, hence we must plant them at once, or we might have only one fat fellow left, who, like Gilbert's mariner, could say:

"O, I am the cook and the captain bold,
And the mate of the Nancy brig;
The bo'sun tight,
And the midshipmite,
And the crew of the captain's gig."

SECTION VIII.

MISCELLANEOUS.

CHAPTER XL.

FROG CULTURE.

About once a year the story of a mythical frog farm, where much wealth is harvested every season, goes the rounds of the newspapers. Seth Green started it in an article on raising frogs, published in one of the Reports of the New York State Fish Commission, stating how easily the spawn could be gathered and hatched; but he went no further; he was widely quoted and that was the end of it, if not the object of his paper. He was right. They can be hatched in any quantity in pools of still water at summer temperatures, and the tadpoles can be fed and grown if protected until the transformation into a frog comes, and then they leave the water and catch insects; it is impossible then to feed them and they die. I speak from experience, having been a student of the frog during a long career of fishculture, covering thirty years. In the early days I read of a successful frog farm near Nutley, N. J., and went there, but no one knew of it, nor could I find the man. A similar experience in Indiana made me skep-

tical, but it was only personal study and experience that made me an unbeliever.

I can feed a single frog by dangling a bit of meat before its nose; the meat stirs and the frog seizes it, but it will not pick up that meat from the ground if thrown there. Suppose you have a million frogs. Imagine yourself feeding them by dangling meat before each individual nose!

Tadpoles are hatched by the thousand for every frog that becomes adult. Fish, birds and frogs feed on them in the larva or tadpole state, and when they emerge from that they encounter the same enemies, with snakes added.

The frog is a solitary animal, never in the company of another except in the spring of the year, when mating, or in the winter, when they congregate in spring holes, or other places. They cannot be kept in numbers, like fishes, because they would starve if obliged to compete for food with their fellows. The frog farm has not yet been established where they can be hatched and fed artificially until ready for market, and it never will be.

When you hear of any person rearing frogs on artificial food it is simply a lie. The frog is being killed out where it is hunted, and the supplies come from remote districts, where the rural population does not eat them, or where there is no population.

According to inquiries of the United States Fish Commission the annual catch in the United States is but little less than 1,000,000, with a gross value to the hunters of about $50,000, or 5 cents each. The consumer pays three times that price, which varies, according to the market. Dressed legs yield the hunters from 10 to 50 cents per pound. The bullfrog is the

largest and best species; the little spring and meadow frogs only grow to 3 and 4 inches, length of body, while the bullfrog reaches nine. The little "pickerel frog" (*Rana palustris*) with bright yellow on thighs and legs, has a disagreeable odor and is rarely eaten; all the others are good. We have four other species, all small except the bullfrog, besides the arboreal frogs, which are usually called "tree toads."

A GREAT TRANSFORMATION.

The change from a tadpole to a perfect frog is as wonderful as the change from a hairy, crawling caterpiller into a beautiful butterfly; but somehow this wonderful transformation into a frog, while well known to a few, has not seemed to impress the general mind, as in the case of the butterfly. What happens is this: The frog lays its eggs, which are fertilized after being laid, as in the case of most fishes; the eggs are globular, jelly-like masses, which swell greatly after extrusion. In a few days the embryo is seen moving about, and it emerges from the mass without absorbing it, a most unusual waste in animal life. The young is coiled in the egg, with a tail, much like an embryo fish, but having its gills outside, and so hatches in an almost shapeless form. Gradually it takes on the form of the large proteus (*Necturus*), called "lizard" on the Great Lakes, which retains its outside gills when adult. Then these outside gills absorb or develop inwardly, and the future frog is in all respects a fish. It has a long embryonic fin that is eel-like, and begins back of the head and goes around the slim tail to the vent. Its eye is well developed, and the "herring bone" mus-

cles in its tail can be plainly seen. It has a circular mouth, which can feed on either animal or vegetable matter. Its abdomen is large, and fitted for digesting vegetables. It rivals the ant in cleaning the flesh from delicate skeletons for the zoologist.

In this state it passes its first summer and goes into the mud in winter, and comes out hungry in early spring. Like all larvæ, it is a greedy feeder, and soon begins to show its growth and development by budding a pair of hindlegs, which are completed about the time the forelegs begin to show and the ears to develop.* When these legs are fully developed the tail begins to absorb, and the frog has already begun to take oxygen from the air occasionally; it is changing from a gill-breathing fish to a lung-breathing animal. Think what this means: Lungs are growing and gills are being absorbed, yet in the intermediate state the animal can breathe with both organs. The absorption of the tail goes to nourish some part of the body, but the adolescent bullfrog is now smaller than the tadpole from which it changed.

Not only this, but its long, convoluted intestine, fitted to digest vegetation, has somehow changed to a shorter one, for the vegetarian requires a complex apparatus to digest its food, while the similar organs in the carnivora are simple, flesh being easier of digestion than vegetables.

MARKETING THE FROG.

Tons of frogs now come to New York markets each year. They are from Canada, Michigan and from the

* The ears of a frog are those large disks back of the eye; they are external ear-drums without a meatus.

West and South, where the people have not yet learned to eat them; for there are practically none to be found near my boyhood frogging grounds, where I could easily get a hundred or more in a day. They do not get a chance to grow, for it is my belief that "an old rouser" of a bullfrog, with a body say 8 inches long, is at least a dozen years old. I can't prove this from experiment, but believe it from the slow growth that several frogs of my acquaintance have made. One that had lost part of one hind foot I knew for three years; it was about 5 inches long when I first caught it, and had not grown over an inch in three years, although in a pool where food was plenty. As about 9 inches is the limit, this frog had not ceased to grow.

In the report of the United States Fish Commissioner for the year ending June 30, 1896, page 497, Dr. Hugh M. Smith gave the products of the fisheries for 1894, and we find the following credited to the frog catch, which, as before said, is mainly sent to New York and other large cities: Arkansas 58,900 lbs., value $4,162; Indiana 24,000 lbs., $824; Missouri 154,818 lbs., $9,676; New York 61,400 lbs., $5,126; Ohio 14,040 lbs., $2,340; Vermont 5,500 lbs., $825. Total, 318,658 lbs., valued at $22,953. No other States are quoted.

Few people outside of the cities eat them. When the rural population take to eating frogs there will be none for the great markets. I have seen whole frogs skinned in Fulton Market, but usually only the hind legs are used; for, except in the case of monster specimens, there is little meat on other parts.

The eggs are extruded by the female, assisted by pressure of the forelegs of the male, who fertilizes them as they pass out.

CHAPTER XLI.

TERRAPINS.

There are many species of terrapins, speaking by the card, but to the market-man and epicure there is but one and this is the "diamond back," so called because of the markings on its upper shell. The flesh of this animal, *Malaclemmys palustris,* is gelatinous and is always stewed. Its almost fabulous price has led to its being hunted so much that it is in danger of being exterminated. It ranges from New York to Texas, but the southern specimens are not in high esteem. Chesapeake Bay furnishes the greatest number, and Baltimoreans not only think them the best but also believe that they cannot be properly served outside that city. Epicures of Philadelphia and New York have the same notion regarding their own cities.

They are sold by the dozen, or computed at that rate, and a "count" terrapin is a female that measures 6 inches in length on the under shell. No male is ever a "count." From this the price increases greatly; a female of 8 inches, which is about the extreme size, being rated as two "counts," more or less according to the market. Twenty years ago the "counts" were worth only the trifling sum of $20 to $30 per dozen, but in 1888 they increased to $75 to $100 per dozen. Suppose that a dozen would weigh 40 lbs., at $100 they would cost $2.50 per pound live weight, the most expensive morsel known in modern days. No wonder that the southern yellow and red-bellied "sliders" come

to northern markets and turn into "terrapin." Who wouldn't?

The terrapins inhabit the salt marshes, and lay their eggs in the sand, as all turtles do, and the young crawl out and go to the water to feed. Their food is mainly fish and crabs. Their threatened extinction has led to efforts for their preservation. It is evident that they must be allowed to lay their eggs in the sand and have the sun hatch them in the good old way, and that all that can be done is to protect the young and perhaps feed them. Senator Stewart of Maryland, had a terrapin enclosure. The *Baltimore American* said: "Messrs. A. B. Riggin & Co. have added another diamond-backed terrapin inclosure on the Annamessex River, adjoining Crisfield, says the *Baltimore American.* The inclosure is formed by driving sixteen-foot boards in the mud to the depth of six feet, or to the hard bottom, making a secure pen for the terrapin. About two acres of muddy bottom are fenced in, with knolls exposed here and there, interspersed with salt water, which is constantly renewed by the ebbing and flowing of the tide. There are also artificial banks of sand in which the terrapin deposit their eggs, leaving them to be hatched by the heat of the sun. Eggs are usually deposited from June to the middle of August, and soon hatch in the warm summer sun. A grown terrapin will lay twelve eggs at a time, and lay twice during the season. Terrapin require about three years to become full "counts."

"During the winter the terrapin plow deeply into the mud and lie dormant, requiring no food or attention, only warm quarters. When they wake up in the spring they develop a vigorous appetite, and are fed principally on hard-shell crabs, which they devour with

great greed. After a few days' feeding they learn to come to the feeding place with the eagerness of chickens in a barnyard.

"At the close of last season the Messrs. Riggin had 3,600 young terrapin on hand, which were carried safely through the winter. The warm days of early spring caused their owners to remove them from the winter quarters sooner than usual, and the cold wave proved very disastrous, killing about six hundred of them, which means a loss, at the present valuation, of $1,200. In purchasing stock terrapin those of five inches cost $13 a dozen; six inches, $34 a dozen, and seven to nine inches, $60 a dozen. They sell at from $60 to $80 a dozen."

There is not room here to record all such experiments as are at hand, the accumulation of years, but the above quotation tells about how far the culture of terrapin has gone. If, under proper conditions, the young can be confined, fed and protected, there may be a future for terrapin culture. The Messrs. Riggin's board enclosure must have had spaces for the entrance of water and food, and just how these were arranged to prevent the exit of young terrapins is not explained. The average newspaper reporter can tell the public all about the culture of fish, frogs, terrapin and other things, if he happens to think of it. He makes a note or two and then takes the hobbles from his imagination and lets it roam. A terrapin is a better climber than an oyster, and "sixteen-foot boards in the mud to the depth of six feet" would secure the diamond-backs, if the water did not rise the other ten feet, a point on which he is silent.

I believe it to be possible to breed this animal profitably. The enormous and ever increasing prices that

genuine diamond backs are bringing will pay for much food and attention. Wealthy men are paying prices for this reptile which almost equal the expenditure of Lucullus for the tongues of nightingales when he merely wished to show his extravagance, for it may be questioned if the tongue of that bird exceeds any other in delicacy; or if the tongue of any bird is a real delicacy. On these points few of us can speak authoritatively. That terrapin culture can be made profitable I do not doubt, as there is no prospect of the price ever dropping from its present height.

CHAPTER XLII.

NUMBER OF EGGS IN DIFFERENT FISH.

SUNFISH.—Once I computed the eggs in a little sunfish. The extreme length of the fish, including the caudal fin, was $6\frac{1}{2}$ inches, and its weight was $5\frac{1}{2}$ ounces. The fish was captured on June 16, and was nearly ready to spawn; the weight of the ovaries was $1\frac{1}{4}$ ounces. The eggs measured twenty-eight to the inch, making 21,952 to the cubic inch. The displacement of the ovaries in water was a trifle over two cubic inches, and the number was estimated in round numbers to be 44,000—a most enormous number for so small a fish.

THE EEL.—Of eel eggs an editorial note in *Forest and Stream,* Dec. 19, 1878, said: "Happening to be in

Mr. Blackford's office a short time ago when a six-pound eel with spawn was brought for examination, Mr. Mather proposed a computation of the eggs. He took the ovary home. Under the microscope the eggs appear to be of an octagonal form, but this is due wholly to their pressing upon one another; when separated they assume the globular form. The use of the micrometer failed to give satisfactory results because the eggs varied greatly in size. Mr. Mather therefore placed a number in line, measured and counted them, and found them to average 80 to the inch. Then he took the whole mass of eggs, halved, quartered, and further divided, seventeen times in all, until the section small enough to count represented 1-131,072 of the total number. The count showed 68 eggs, or 8,912,-896 in the whole. A second computation in the same way showed 77 eggs in the counted mass, or 10,092,544 altogether. And to make the computation still more certain, a third count was made, which showed 71 eggs in the last division, or 9,306,112 in the whole ovaries. From these results Mr. Mather fixes the number of eggs in this particular eel at fully nine millions."

The eel goes to salt water to breed, and while we do not know how its eggs are deposited, we know that it passes through a larval state, the very young having been considered to be a distinct animal by the older naturalists.

TABLE OF THE NUMBER OF EGGS IN VARIOUS FISHES.

The following is taken from the "Manual of Fish-culture" of the United States Fish Commission, omitting such fishes as have little importance, or whose

eggs have been mentioned in other parts of the book, and using "free" for "non-adhesive."

Name of Fish.	*Character of Eggs.*	*Average Number per Fish.*	*Maximum Egg Production.*	
			Number of Eggs.	*Weight of Fish.*
Atlantic Salmon.....	Heavy, free.....	9,363	20,992	$22\frac{11}{16}$ lbs.
Black Basses.....	Heavy, adhesive..	3000 to 10000	.....	.....
Crappies.....	Heavy, adhesive..	.....	.....	.....
Frost-fish, *Coregonus.*	Heavy, adhesive..	.....	.....	.....
Grayling.....	Heavy, free.....	3000 to 4000	5,200	$1\frac{1}{2}$
Mackerel.....	Buoyant, free.....	41,000	546,000	$1\frac{1}{2}$
Muskellunge.....	Semi-buoyant, slightly adhesive	100,000	265,000	35
Whitefish.....	Semi-buoyant, free.....	35,000	.....	.....
*White Perch.....	.....	40,000	.....	.....

* The table gives the eggs of this fish as "buoyant, non-adhesive." I have written that they adhere to "floating sticks, weeds, etc.," and this is right.—F. M.

CHAPTER XLIII.

THE "WORKING," OR "BLOOMING" OF PONDS.

Anglers find that at certain times in summer there is a condition of things in large natural ponds which seems to deprive the fish of all desire to take food. In *Forest and Stream* of Aug. 27, 1898, several correspondents referred to this, and I will condense their remarks here, as they show the different phases of this little understood but very common occurrence.

Mr. A. L. Jordan leads off with some questions, a statement of fact, and a final question. He says:

"May I be allowed to ask through your columns a

few questions concerning the working of ponds, and the method of fishing the ponds when in that condition? I very much desire to solve the problem of the whys and wherefores of a pond's working. What is the cause of a pond's working? What good does it accomplish? How does it affect the habits of trout or any fish? What is the best method of fishing during the pond's working?

"I have been for the last three years on Lake Twitchell, near Big Moose, in the Adirondacks, during the latter part of August and the first part of September. Last year the condition of the lake was exceedingly bad, an old guide saying he had never seen any lake in such a condition. What I term the workings were all over the bars and were from 3 to 5 or 6 feet tall, growing to within a few inches of the top of the water. They were of a substance somewhat yellowish in color, and of a thick, slimy nature. After a heavy wind the shores would be covered with a lot of black stuff washed ashore.

"The trout in this water were slow and sluggish, and not particularly anxious to please the fisherman with a rise to his cast. When opened they had no visible traces of the food they were feeding upon, and they were very fat and in a good condition. It was their custom to break water at sunset, but this year they would even forego that sport. What caused this inactivity?"

Mr. L. O. Crane also wants to know about the "specks" in the lakes and ponds during July and August, when the fishing is poor, and adds: "Some say the specks are caused by the lakes fermenting; others say they are caused by a plant blooming in the bottom of the lakes, and others by the blow from trees coming

into the lake. Please set us all right on this point that I have heard discussed so long."

Then the following appears: "I find in Bulletin U. S. F. C., Vol. VI., p. 341, a paragraph upon the 'water bloom' of ponds, from which I quote:

" 'Lower forms of algæ, of the varieties *Nostochaceae, Oscillariae* and *Chroococcaceae,* occasionally produce by their astonishingly rapid growth the so-called 'water bloom' (*Wasserbluete*), and transform the water into a blue-green mass resembling oil. Sometimes this 'water bloom' causes the death of all the fish in a pond; in other cases only certain varieties die, and frequently the fish are not at all affected by it. So far no experiments have been made with the view to ascertain which of the algæ forming the 'water bloom' exercise an injurious influence on fish. It is therefore very desirable that careful observation should be made in this respect.'

"In the United States no doubt similar effects are produced by related forms of algæ. It is usually stated that the seeds of certain water plants float at the surface of ponds and make the water cloudy until fertilization increases their specific gravity, when they sink to the bottom and continue their development."

The German authority quoted is Dr. Berthold Benecke, formerly living at Königsberg.

This last writer is close to the facts, and it may be that in some cases, unknown to me, the water may have resembled oil. But now comes Judge J. S. Van Cleef, of Poughkeepsie, N. Y., who is closer yet, and hits the bulls-eye in the following remarks:

"I think that I can answer quite fully your question in regard to what you call the 'blooming' of ponds, but which is more commonly called 'working or clouding.'

This condition of the water does not always result from the same cause, but I am satisfied that it results from one single cause in the pure water lakes of the mountain regions of the Catskills. In the Bay of Quinte the blooming of the water evidently comes from the spores of an aquatic weed or plant which abounds in all the shallow waters of that bay. So far as I have had the opportunity for observation almost every lake, pond or water abounds in aquatic weeds peculiar to itself. Where the water is not over about 4 feet in depth these plants abound in a large amount of insect life, and where the water is deeper there is, as a rule, an entire absence of animal life. In the waters of the Catskills, with which I am quite familiar, I have never known of a single case where these weeds or plants throw out spores of any kind which cloud the water. Mr. Cornelius Van Brunt, who is quite an eminent misroscopist, and I, some twenty years ago or more, took particular pains to find out what caused the clouding of the waters in two of the lakes of the Catskills, Balsam Lake and Willewemoc Lake, and in both cases we found that this clouding was caused by the spores of the fresh-water sponge, which abounded in both lakes.

"The waters of these two lakes, like most of the lakes of the Catskills, were very pure, being spring water, and on the bottom of the lakes, at a depth of about 2 feet or 2½ feet, this fresh-water sponge existed in considerable abundance, each sponge being not over 2 or 2½ inches in length by 1 or 2 inches in width, and when taken in the hand and squeezed there seemed to be nothing of them. The clouding of the lakes was found to extend down from 6 to 12 inches, and to be produced by millions of spores thrown out by the fresh-

water sponge; and as I understand it, they are thrown out with very great rapidity, and the lakes where these sponges exist remain clouded until there comes a decided storm, when the spores are precipitated to the bottom of the lake, and the water becomes perfectly clear again in two or three days.

"In my testimony in regard to Forest Lake, near Hudson, N. Y., I referred to the fact that this lake was free from cloud, and that from a personal inspection of the lake I had failed to find any fresh-water sponges. In regard to this examination I can only add that the examination of the waters of these lakes was made under a microscope of the highest magnifying power suitable for such a purpose, and that no spores were found except those produced by the fresh-water sponge."

After this an invitation was extended to me to say something on this subject by a friend, who wrote: "No doubt you saw the different theories about the working of ponds in a late *Forest and Stream*. What do you think of them? Who is right?"

My answer was: "All are right. There are different causes for this disturbance of the water. One year the mill-pond at Cold Spring Harbor, Long Island, bloomed twice, once in the middle of July, from Nostoc, which lasted four days, when the water cleared and the bass and perch were just coming to their appetites, when early in August it bloomed again with the fresh-water sponge, as described by Mr. Van Cleef. During the last bloom many sunfish and some white perch died, and the bass and yellow perch seemed to abstain from food, certainly from baits offered, until September. There is a theory that the pollen from some trees—ash, I believe, is one—cloud the water at

times and the fish then refuse all baits. I know nothing of this.

"Nostoc, or Nostochacex, as the quotation from the Bulletin of the U. S. Fish Commission has it, is a low form of vegetation which grows in fresh water and on damp ground. It is jelly-like, and is composed of threads which consist of globular cells, between a dozen or more of which are larger cells, and these are thrown off and float by thousands in the water. On land I have seen masses of it in the swamps from 3 to 5 inches in diameter, covered with jelly, and so like the egg-masses of *Amblystoma,* or salamanders, which are often improperly called 'lizards'—the true lizards have scales, and do not live in water, but love the sun—that one had to look twice to tell the difference. Nostoc is of a bluish or greenish color, and the egg bunches referred to are whitish, slightly opaque. There are many species of Nostoc, but all have the characters given above.

"The fresh-water sponges, as Mr. Van Cleef says, throw off great quantities of spores and cloud the water. These sponges also have many species, are very tender and difficult to detach from wood or stone, for preservation entire, because they are so tender. Being animal, their decay often renders the water in the reservoirs of cities very foul and 'fishy.' Then people complain of the fish in the reservoirs, but live fish do not pollute water."

In Germany this condition of ponds is called "wasser-bluthe"; in France, "Fleurs d' Eau," and in England "Blooming," or "Breaking," or "Cruddling." The London *Fishing Gazette,* Mar. 11, 1899, in an article on this is quoted:

"At certain times in each year, generally in autumn, the Shropshire meres become turbid with these green

particles, the water becomes unfit for domestic purposes, and it defies the power of filtration, soon clogging up the pores of filters. Fish become sickly in it, and in some instances die, and in others are easily caught.

"A Mr. Southwell relates that in a lake of about five acres, in very hot weather in June, the lake broke, and there shortly appeared on the surface large numbers of eels, which attracted the attention of the villagers, who took to the boats, and with spears and other implements many were captured, quite in a sickly and stupefied condition.

"This condition of things continues in varying periods from a few days to months. After a time the water emits a very putrid odor from the decomposition of the green particles. In Copmere last year the turbidity commenced about the middle of July, and it was not until the middle of October that it subsided, after which the mere cleared and seemed to have undergone a veritable purification by the process, so much so that it conveys the impression of being a sanitation of Nature to purify the silted organic deposits which almost fill these meres.

"Copmere was about fourteen days before the decomposition of the green scum set in; the surface of the water then began to give off a putrid odor. The prevelence of these green appearances is variable. They disappear and reappear, and occur in greater quantities in various parts of the Shropshire meres, but in Copmere last year they were generally diffused throughout. * * * Copmere did not break in 1895, it remained very clear all summer and autumn; but a very singular fact is connected with this exception of breaking, in that a great quantity of fish died

that year of a fungus-growth disease, whereas in 1896 none died, notwithstanding the mere broke badly.

"It is said of Blake Meer, one of the meres near Ellesmere, that this phenomenon does not occur, and the water there is selected for drinking purposes, while the other meres are in the breakage state. * * * You will now be prepared to know that this breaking of the meres is due to microscopic algæ, of which various species cause the phenomenal appearance. Dr. Drummond found the green color of the water of Lake Glaslough in Ireland owing to vast quantities of a flocculent oscillating algæ. In Loch Hainining in Selkirkshire a rich purple color occurs on the surface owing to the presence, according to Dr. Greville, of an alga of the genus *Lyngbya*. In a loch near Aberdeen a species of *Rivularia* caused the peculiar appearance; another species, *Anabæna* flos-aquæ, was also present."

See chapter on diseases.

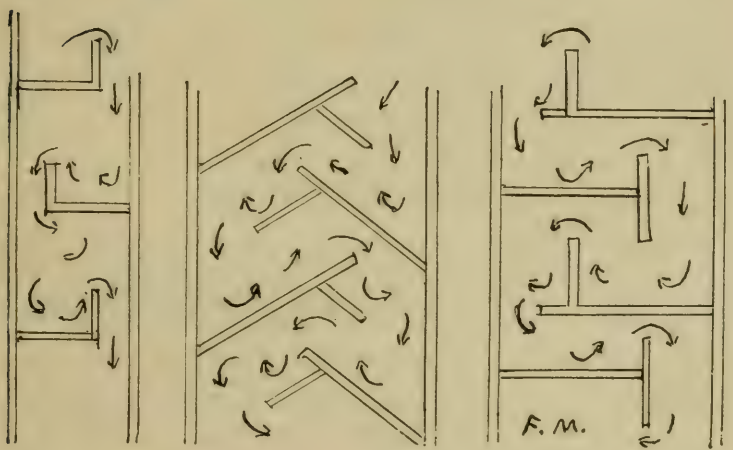
CHAPTER XLIV.

FISHWAYS.

A small fishway, or, as some call it, a "fish ladder" is often needed by the fishculturist to enable fish to surmount a dam. If possible this should be above the dam, its upper end extending into the pond, or many fish will pass its outlet and remain at the dam vainly trying to ascend. Space forbids going into this question *in extenso*, but as a 6-foot dam, having a fishway

with a rise of one in six, which is quite steep, would have the way extend 36 feet down stream it will be seen how easily fish might go past it, and that is a moderately steep gradient, if possible make it one in ten. With dams alternately projecting from each side, as shown, the force of the water is broken and eddies are formed which permit the fish to rush, rest, and so ascend. There are more complicated forms of fishways, some patented, but for a little trout stream this simple form will do.

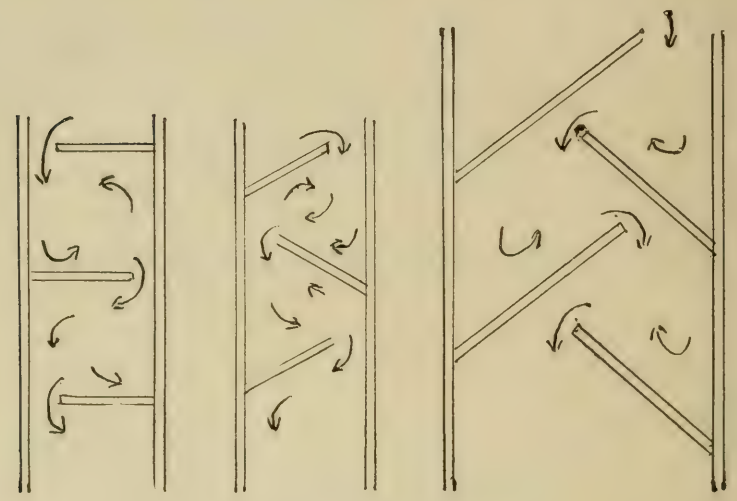
If it is desirable to stop all kinds of fish from ascend-



Forms of Fishways.

ing, a trap at the top can be arranged and the fish assorted. Some figures of different devices are here given. Those who wish to pursue the subject further are referred to the Reports of the U. S. and State Fish Commissions. The McDonald fishway—as he patented it but did not invent it the name is legitimate—I believe to be the best form if properly built and protected. It is too complicated for small ways such as

private ponds require. The State of New York had one on the Hudson, at Troy, but it was poorly made, was bolted to the apron of the dam, and, when that



FORMS OF FISHWAYS.

floated up, the foot of the fishway was in the air. The figures show several models for retarding the water.

CHAPTER XLV.

FISHES WHICH GUARD THEIR YOUNG.

A correspondent asks: "Is there any other fish besides the dogfish which guards its young?" He refers to the fresh-water dogfish, *Amia calva,* called in the West and South lawyer, bowfin, John A. Grindle and

Johnny Grindle, while in Vermont it is the "mudfish." Of this fish Mr. Charles Hallock says in his Sportsman's Gazetteer: "While the parent still remains with the young, if the family become suddenly alarmed, the capacious mouth of the old fish will open, and in rushes the entire host of little ones; the ugly maw is at once closed and off she rushes to a place of security, when the little captives are set at liberty. If others are conversant with the above facts, I shall be very glad; if not, shall feel chagrined for not making them known long ago." Mr. Hallock's book was printed in 1877, and I do not remember to have seen this matter referred to since, except that his remarks are quoted in the Fisheries Industries (1884), Section I., page 659.

There are many fresh-water fishes which guard their young, and it is my belief, based on the capture and dissection of many individuals, that it is the male which does the guarding. All the catfish tribe guard their young until they scatter, swimming below the little black school for several days. Black bass, rock bass, sticklebacks and all the sunfishes guard both eggs and young until the brood separates in search of food. It is possible that the crappies also guard their young, but I do not know their habits in this respect.

There is a beautiful little fish in India, brought here for ornamental purposes, called paradise fish. I have bred them in small tanks; the male makes a floating nest of air bubbles among the weeds and coaxes the female to deposit her eggs therein, but after she has done that he will not let her go near the nest, and hunts her to the furthest corner, sometimes killing her. He fans the eggs, and when the young hatch and wander from the nest he will take them in his mouth and return them. Some of the sticklebacks make elaborate

nests of twigs and the male takes entire charge of the household.

The male sea-horse, *Hippocampus,* has a pouch like a marsupial, in place of an anal fin, in which the female lays her eggs and he cares for them and their young. The males of some tropical fishes are said to carry and hatch the eggs in their mouths.

CHAPTER XLVI.

HOW FISH FIND THEIR OWN RIVERS.

On this subject the late Professor James W. Milner wrote some years ago in *Harper's Magazine*, and really nothing more is known about it to-day. He said: "The long held and only recently rejected theory that the shoals of fishes moved in a vast mass along the coast, sending off detachments into each river as they passed its mouth, is to be attributed to John Gilpin and some other authors, who have written flowingly on the subject. The recent careful investigations of naturalists indicate that the anadromous fishes, those entering the rivers and bodies of fresh water from the sea, do not have an extended range in the ocean, and that each river's colony remains, after returning, in the deep waters opposite their river. The motive for the movement of these shoals of anadromous fishes, or rather how it is incited, has scarcely been explained. The life of the fishes has always been a mystery. It is not a search for food, as they do not eat while in fresh water;

the opening of hundreds of stomachs will fail to find food present. It is an easy disposal of the question as to how each colony recognizes its native river to say that 'it is instinctive.' So it is, also, when the butcher's horse recognizes the familiar gates; but we have some evidence as to what senses he uses. The fishes, probably prompted by functional disturbance from the tumid ovaries and spermaries, are incited to movement. The courses of the sea, unmarked as they are, are, within each colony's limit, their habitual pathways. An unerring capacity in the fish for finding its own river may be no more than that which guides the hermit-crab to the shell of the natica. The latter goes to hide its sensitive body, with an apparent nervous trepidation at its unprotected condition. The former, with an uneasiness of body from the functional changes it is undergoing, is impelled to activity. The transmitted habit of ascending the stream is, as it were, blended and alloyed with the substance of the nerves, and, aroused by its condition, carries it, without conscious purpose, into the river of its progenitors and its own. The impulses of the fish are only in a slightly more complicated series than those of the crab. That it should be the instinct for a specific stream, established through inheritance of many generations, is easier to understand than that it is a sort of memory of the place of its immature life, as the theory of fishculture makes it and as observation seems to sustain. In the waters of the Delaware, where there were no salmon originally, the young salmon placed in Bushkill Creek returned after five years and were taken, not only in the Delaware River, but the larger number in the neighborhood of Bushkill Creek. It is not essential that all fishes should have this impelling influence, whatever it may

be, as, like gregarious mammals and birds, they flock together, following the leadership of whichever for the time takes it. The idea is suggested that the senses may be the guiding agent, that a fish goes nosing along the coast, or tasting the streams, until it recognizes its own. The convexity of the cornea must afford the fishes a very limited range of vision. The supposed dullness of the sense of smell and of taste in fishes might alone dispose of the suggestion that these are employed. The following occurrence, however, would seem to decide to the contrary: The Russian River, emptying into the Pacific, north of San Francisco, had its mouth entirely closed by the waves during the storm. The colony of salmon made their yearly migration from the deep waters toward the mouth of the river, and many of them raced through the surf and landed high and dry on the sand that walled them out from their native river. The migration of the salmon into some of the Pacific rivers is a frenzied advance over shoals, rapids and cascades, far into thin streams and brooks, where they arrive battered and weary, to accomplish their exhaustive reproductive labors and drop back, the sport of the current, dead and dying, toward the sea."

CHAPTER XLVII.

DYNAMITING A LAKE.

Hodge Lake, on the head waters of the Willowemoc, Sullivan Co., N. Y., was populated with eels, pickerel,

catfish, perch and sunfish. The owner wished to clear his pond of all these, render it lifeless and then restock it with trout, for the waters were cool enough in summer! In April, 1899, 200 holes, fifty feet apart, were cut through the ice and dynamite in half-pound sticks, twelve to each hole, were lowered to within four feet of the bottom. Each lot of sticks was connected by wire to electric batteries, so arranged that there would be three explosions about half a second apart. The button was pressed and columns of ice and water, from 10 to 15 feet in diameter, went up a hundred feet or more. The concussion shook the earth about the shores and the lake was barren of fish, insect larvæ and crustaceans. The larvæ will all come back, but the owner will have to see to the vegetation and the crustaceans. If he gets his plants from neighboring lakes of the same character he will get all these forms entangled in it without paying further attention to them.

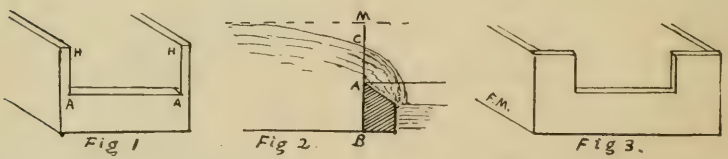
CHAPTER XLVIII.

TO MEASURE A FLOW OF WATER.

Often a correspondent seeks advice about trout ponds and to a question regarding the highest temperatures and the amount of water flowing in the driest time, replies that he is ignorant on these points. The temperatures he can get with more or less accuracy, dependent on the unreliability of cheap and untested thermometers; but the amount of flow is usually a

matter of wild guessing. An expert can guess with some nearness by a mental estimate of how long it would take a stream to fill a certain tank, but this is only a guess. I had seen tables given in an algebraic form, which, as far as I am concerned, might as well never have been written, for, while as a schoolboy I was forced through such studies, I promptly forgot them. Anything mathematical was too heavy for a brain not fitted to bear such burdens. Yet I must tell in this book how to do the trick with exactness, and the occasion brought the man, as usual. I wrote to a friend, Mr. W. B. Osterhout, of Freeport, N. Y., one of the engineers of the Brooklyn Water Works. He writes:

"Col. Fred Mather: It gives me great pleasure to comply with your request of March 30. The formula of which you speak is known as Francis' formula and is for measuring the discharge of water over a weir: $Q=3.33\times L\times H^{\frac{3}{2}}$ or $Q=3.33\times L\times \sqrt{H^3}$: Q= Cubic feet of water per second; L=Length of weir; H=Head or depth of overflow.



"The conditions are: The inner face of weir, as A B (Fig. 2), must be not less than twice the depth of overflow, as A M measured from A to horizontal portion of water's surface, A to M, and not to curved surfaces, at C, and the length of A A of weir (Fig. 1) not less

than three times the head, A M. The formula given is for a weir without end contractions, as Fig. 1; that is, the width of flume leading to weir must be the same width as the overflow and not contracted, as in Fig. 3. After getting Q, or cubic feet of water flowing per second, it is easily reduced to gallons flowing per minute, hour or day. As there are 1,728 cubic inches in a cubic foot and 231 cubic inches in a gallon, a cubic foot of water contains 1,728 inches divided by 231 inches, or 7.4805194 gallons, or nearly 7½ gallons. The flow is generally calculated for the number of gallons per day of twenty-four hours."

There must be other mathematical dunces, and so I wrote Mr. Osterhout that his formula was no doubt correct, but was not in the shape to be "understanded by the people"; also that fishculturists reckoned the flow per hour, and that if he would kindly translate this formula into a flow per hour per foot width of dam it would just hit the mark.

Then he got down to the fishcultural level and wrote:

"Col. Fred Mather: Your mathematical difficulties are appreciated and I enclose you a table, showing gallons per hour discharged by a one-foot weir for depths from 0 to 1 foot. I have also put in the decimal of a foot corresponding to each half inch. For any weir other than one foot in length multiply the number of gallons opposite any head by length of weir.

"*Example.*—How many gallons per hour will flow over a 4-foot weir, with a head of 3½ inches? 14,128 × 4 = 56,512 gallons. If the weir is 4 feet 5 inches long, the 14,128 for a head of 3½ inches must be multiplied by

4.4167, the decimal .4167 being equivalent to 5 inches, which is shown in the first column."

Now that my engineering friend had got down to the water level of the fishculturist, there was nothing to do but to give his latest formula, and here you have it in his own words:

FRANCIS' FORMULA:

Discharge in cubic feet per second = 3.33 × length of overfall in feet × $\sqrt{\text{cube of head in feet.}}$

Discharge in gallons per hour = 3.33 × by length of overfall in feet × $\sqrt{\text{cube of head in feet}}$ × 7.4805 × 3,600.

7.4805 = number of gallons in one cubic foot of water or very nearly 7½.

3,600 = number of seconds per hour.

Discharge in gallons per hour of a weir one foot long without end contractions for depth from 0 to one foot.

Head in Feet.	*Head in Inches.*	*Gallons per Hour.*	*Head in Feet.*	*Head in Inches.*	*Gallons per Hour.*
0.0417	½	764	0.5417	6½	35,753
0.0833	1	2,156	0.5833	7	39,950
0.1250	1½	3,963	0.6250	7½	44,310
0.1667	2	6,104	0.6667	8	48,817
0.2083	2½	8,525	0.7083	8½	53,457
0.2500	3	11,210	0.7500	9	58,246
0.2917	3½	14,128	0.7917	9½	63,171
0.3333	4	17,256	0.8333	10	68,215
0.3750	4½	20,593	0.8750	10½	73,399
0.4167	5	24,122	0.9167	11	78,708
0.4583	5½	27,823	0.9583	11½	84,126
0.5000	6	31,705	1.0000	12	89,676

ADDENDA.

JANUARY 1, 1900.

GROWTH OF TROUT.

We are always learning, and in 1899, after what I have written, I went to the northwestern corner of Wisconsin, up the Brule River, to take charge for a short time of a large trout preserve belonging to a gentleman living in St. Louis. Fishcultural operations had been going on for several years previous, and the yearling trout were only 2½ to 4 inches long; while the two-year-olds would not average over 6 inches. They had been well fed, but the water was cold and they had not the appetites of the trout of the warmer waters of Long Island.

The springs were 43° Fahr., and the pools in summer never rose above 50°. These pools were made at the outlet of a small pond of some 4 acres and in swift water. If I should remain here, as I shall not, I would make the rearing pools where there are no springs, and where the ice makes thickest in winter. This would give warmer water in summer and a greater consumption of food; consequently a greater growth.

The water in hatching troughs there, up to Jan. 1, 1900, has varied from 38° to 36° Fahr., more often at the lower figure.

GRAYLING.

Since the book was in type I have had further experience with the grayling. The eggs came from Montana to northern Wisconsin in May, 1899, in very bad shape. Of the few hatched a very small number lived to take food, and of these 80 per cent. died before the close of the year. Mr. S. P. Wires, Superintendent of the U. S. F. C. Station at Duluth, Minn., has no liking for the fish, if he is expected to feed and raise it. Mr. Frank N. Clark, of the Michigan stations, is of the same opinion. They find the eggs hatch well enough, but beef liver is not the food for them, and the best thing to do is to turn them out when they begin to take food, and this is my more mature view of the fish. My first experience was somehow more fortunate than that of later years. All agree that the adult fish does not mature its eggs in confinement.

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